Cookies

We use some essential cookies to make our website work. We'd like to set additional cookies so we can remember your preferences and understand how you use our site.

You can manage your preferences and cookie settings at any time by clicking on "Customise Cookies" below. For more information on how we use cookies, please see our Cookies notice.

Accept cookies | Reject cookies | Customise cookies

Your cookie preferences have been saved. You can update your cookie settings at any time on the cookies page.

Your cookie preferences have been saved. You can update your cookie settings at any time on the cookies page.

Close

Sorry, there was a technical problem. Please try again.

Request an intellectual property (IP) licence

Request an intellectual property (IP) licence

Progress

Review

- Your details
- Your request
- Review

To understand how your data is collected and handled read our privacy notice.

Review

Back

Review

Review

Your details | ChangeYour details

Your details

Title

Ms

First name

tshingombe

Surname

tshitadi

Company name

engineering

Email address

tshingombefiston@gmail.com

Phone number

0725298946

Your request | ChangeYour request

Your request

Select the option that most applies to you

Request an intellectual property (IP) licence to use a trademark belonging to the Met or Mayor's Office for Policing and Crime (MOPAC) for any purpose

Details of your enquiry

tshingombe tshitadi Prospect ID : 0403202420596660738001 0884bebd2415f9d5d6b20c80a2237 Postdoctoral in 0 First Name : tshingombe Last Name : tshitadi Email : tshingombefiston@gmail.com Alternative Email : Address 1 : Address 2 : City : Johannesburg State : Country : South Africa Home Phone : Work Phone : Cell Phone : 0725298946 Fax : Age : 42 Gender : Website Address : Language : English Internal Comments : The AIU AI Program Generator creates custom program courses based on your desired work field and educational background. This intelligent tool tailors a curriculum to align with industry demands and your academic strengths, ensuring efficient learning and maximizing your potential for career success. The program generator offers a preview of potential courses at AIU, each with several lessons. Once enrolled, students can customize courses during Phase 2 by collaborating with their tutor and advisor. This ensures a personalized educational experience tailored to their unique needs and goals at http://aiu.edu. Course Name Description Date Action Clean Energy Technology: Ecotechnology Applications This course provides an in-depth understanding of .... 02/06/2025 Integration of Electronic Engineering in Construction and Civil Engineering This course aims to explore the integration of ele .... 02/06/2025 Masters in Immutable Data Storage Solutions for Web Design This course provides an advanced understanding of .... 02/06/2025 Advanced Cyber-Physical Systems in Telecommunications This course explores the intersection of cyber-phy .... 02/06/2025 Master's Program in Artificial Intelligence and Machine Learning for Software Engineering This course provides an in-depth exploration of ar .... 02/06/2025 Advanced Studies in Autonomous Vehicles and Drones for Electric Vehicle Engineering This course provides an in-depth exploration of th .... 02/06/2025 Specialist Engineering in Infrastructure and Contractors: Electrochemical Engineering This Master's degree course offers in-depth knowle .... 02/06/2025 Energy Storage and Battery Technology This course explores advanced concepts in energy s .... 02/06/2025 Advanced Robotic Process Automation in Electrical Engineering This course aims to equip students with advanced k .... 02/06/2025 Master's in Artificial General Intelligence and Social Sciences This course aims to explore the intersection of Ar .... 01/28/2025 Online Retail and E-commerce in the Renewable Energy Sector This course explores the intersection of online re .... 01/28/2025 Publishing and Natural Resources Management This Masters-level course is designed to explore t .... 01/28/2025 Masters in Supply Chain Management and Traceability This course is designed for students pursuing a Ma .... 01/28/2025 Social Media Marketing for Real Estate, Rental, and Leasing This course is designed to equip students with the .... 01/28/2025 Advanced Telemedicine and Remote Healthcare Production This course is designed for Master's students focu .... 01/28/2025 Technical Writing for Technology This course is designed to prepare students with t .... 01/28/2025 Masters in Vertical Farming and Urban Agriculture with Focus on Synthetic Biology This course explores the intersection of vertical .... 01/28/2025 Master's in Urban Water Supply, Sewerage, Waste Management, and Remediation Activities This course delves into the complexities of urban .... 01/28/2025 Transportation and Warehousing in Tourism Planning and Development This course offers a comprehensive study into how .... 01/28/2025 Spatial Computing in Telecommunications This course explores the integration of spatial co .... 01/28/2025 Advanced Pedagogical Training for Professionals in Scientific and Technical Services This Master's course is designed to equip individu .... 01/28/2025 Advanced Mechanical Engineering for Space Exploration and Aerospace This Master's level course provides an in-depth un .... 01/28/2025 Advanced Legal Studies in Public Administration and Safety This course is designed for Master's level student .... 01/28/2025 Metallurgy in Oil and Gas Production, Refining, and Transport This course provides an in-depth understanding of .... 01/28/2025 Integrated Water Management in Mining This course provides an in-depth analysis of integ .... 01/28/2025 Advanced Manufacturing Techniques in Genetic Engineering This course explores the convergence of manufactur .... 01/28/2025 Data Processing and Hosting Services in Computer Engineering This course is designed for graduate students purs .... 01/28/2025 Masters in Cryptocurrency and Blockchain Applications This course provides an in-depth exploration of bl .... 01/28/2025 Advanced Cybersecurity in Bibliotechnology This course explores the intersection of cybersecu .... 01/28/2025 Edge Computing in Modern Power and Energy Systems This course provides an in-depth exploration of ed .... 01/28/2025 Edge Computing for Modern Power and Energy Systems This advanced course explores the role and integra .... 01/28/2025 Masters in Cyber-Physical Systems and Information Technology This course provides an in-depth understanding of .... 01/28/2025 Masters in Distributed-Ledger Technology Applications in Educational Technology This course explores the integration of distribute .... 01/28/2025 Master's in Adult Education Services This course is designed for educators and professi .... 01/28/2025 Quantum Computing in Systems Engineering This course provides an in-depth exploration of qu .... 01/28/2025 Neurotechnology in Educational Technology This course explores the intersection of neurotech .... 01/28/2025 Robotic Process Automation in Electrochemical Engineering This course explores the integration of Robotic Pr .... 01/28/2025 Integrating Educational Technology in Renewable Energy Studies This course is designed for master's students inte .... 01/28/2025 Wholesale Trade Management in Industrial Engineering This course is designed for students pursuing a Ma .... 01/28/2025 Advanced Wireless Communications This course explores the fundamental principles an .... 01/28/2025 Advanced Electrical Engineering in Construction and Civil Engineering This course provides an in-depth understanding of .... 01/28/2025 Electrical Systems in Construction and Civil Engineering This master's level course is designed to bridge t .... 01/28/2025 Doctorate in Specialist Engineering Infrastructure and Contractors: Electrical Engineering This advanced course is designed for students purs .... 11/22/2024 1. Users Table: - user_id : 0403202420596660738001 0884bebd2415f9d5d6b20c80a2237 - username:tshingombe - email:tshitadi - password: kananga5 - address 2. Products Table: - product_id : 0403202420596660738001 0884bebd2415f9d5d6b20c80a2237 - name: engineering - description: circulum assessment - price: 1000$ - category_id:45677 3. Categories Table: - category_id : 0403202420596660738001 0884bebd2415f9d5d6b20c80a2237 - name 4. Orders Table: - order_id : 0403202420596660738001 0884bebd2415f9d5d6b20c80a2237 - user_id :9879 - order_date:25/02/2025 - total_amount 5. Order_Items Table: - order_item_id : 0403202420596660738001 0884bebd2415f9d5d6b20c80a2237 - order_id : 123456 - product_id:tshi - quantity:100 - item_price :100000$ ---------- 1.Topic one experimental: theoretical pratical company Overview : tshingombe fiston Sat, Nov 30, 2024, 5:38 PM to regionArevenue, regionBrevenue, tenderadvicecentre, estimations, wmcqueries, Mediadesk, SARS, me City Power is responsible for providing electrical services to property owners in the City of Johannesburg that are not serviced by Eskom. To determine if you are a City Power customer you can check your existing City of Johannesburg invoice and see if you are being billed for electricity. If you don't have an invoice or if you don't have a service connection you can check the township list, it will indicate in whose supply area the property is. The service connections we provide are divided into two categories namely Small Power Users (SPU) and Larger Power Users (LPU). A Small Power User is defined as a user who has an electrical service connection no greater than 56 kVA (3 phase, 80 ampere). In general most households would have this type of service connection. A Large Power User is defined as a user who has an electrical service connection larger than 56 kVA. In general these type of connections are used for medium and large commercial or industrial consumers as well as high density residential developments. We want to provide property owners with the services they require in as short time as possible. To assist with this, the information and documents required to make an application for electrical services are detailed in the documents on this webpage. 1. Apply to convert a SPU from postpaid to pre-paid billing 2. Apply for a new prepaid or postpaid SPU connection (this guide also covers application for alterations to a small power user connection) 3. Apply for a new LPU connection (the guide also covers applications for alterations to a large power user connection) The application form that needs to be submitted when making an ☐new feed updates notifications ☐Sales Nav City Power Johannesburg Visit website ☐Home ☐About ☐Posts ☐Jobs ☐People ☐Insights City Power Johannesburg Customer-focused energy services company, operating and maintaining the Johannesburg's electricity distribution network. Electric Power Transmission, Control, and Distribution Johannesburg, Gauteng 1K followers 1K-5K employees Visit website ☐Home ☐About ☐Posts ☐Jobs ☐People ☐Insights City Power Johannesburg 1,034 followers See a collection of active or past ads by City Power Johannesburg. View ad library Feed post number 1 City Power JohannesburgCity Power Johannesburg 1,034 followers1,034 followers 2w • 2 weeks ago City Power's Green Energy Future: Solar Microgrids Empower Communities hashtag#CityPowerServices hashtag#CityPowerEnergyPlan City Power's Green Energy Future: Solar Microgrids Empower Communities City Power Johannesburg By Kgagodi MadibaCity Power is taking significant strides to reduce greenhouse gas emissions and bring sustainable energy solutions to Johannesburg co /☐ ☐ Home ☐ ☐ My Network ☐ ☐ Jobs ☐ 1 1 new message notification ☐ Messaging ☐ 25 25 new notifications ☐ Notifications ☐ ☐ ☐ ☐ ☐ application can also be found with the downloadable documents on the below table. On Sat, Nov 30, 2024 at 5:11 PM tshingombe fiston wrote: https://www.sars.gov.za/businesses-and-employers/trusts/registering-as-a-trust/register-a-trust-supporting-documents/ 4 Attachments • Scanned by Gmail tshingombe fiston On Sat, Nov 30, 2024 at 5:38 PM tshingombe fiston wrote: City Power is responsible for providing electrical services to property ow Nov 30, 2024, 5:42 PM tshingombe fiston On Sat, Nov 30, 2024 at 5:38 PM tshingombe fiston wrote: City Power is responsible for providing electrical services to property ow Dec 1, 2024, 12:17 PM postmaster@sap.onmicrosoft.com Delivery has failed to these recipients or groups: SARS Human Capital and Development (System@successfactors.com) The recipient's mailbox is full and can't acce Dec 1, 2024, 12:19 PM tshingombe fiston Turn on more accessible mode Skip Ribbon Commands Skip to main content Webmail Contact Us Sign Out - HomeCurrently selected - Our Company - Company Information Dec 1, 2024, 12:52 PM Mail Delivery Subsystem Message blocked Your message to sarb-graduaterecruit@resbank.co.za has been blocked. See technical details below for more information. LEARN MORE This link will Dec 1, 2024, 12:53 PM Mail Delivery Subsystem Message blocked Your message to admni@resbank.co.za has been blocked. See technical details below for more information. LEARN MORE This link will take you to a Dec 1, 2024, 12:53 PM Mail Delivery Subsystem Address not found Your message wasn't delivered to customerservice@eskom.co.za because the address couldn't be found, or is unable to receive mail. LEARN MORE T Dec 1, 2024, 12:53 PM Mail Delivery Subsystem Address not found Your message wasn't delivered to GITServiceDesk@eskom.co.za because the address couldn't be found, or is unable to receive mail. LEARN MORE Th Dec 1, 2024, 12:53 PM postmaster@dmre.gov.za Your message to examweb@dmr.gov.za couldn't be delivered. The group examweb only accepts messages from people in its organization or on its allowed senders list Dec 1, 2024, 12:53 PM postmaster@sap.onmicrosoft.com Diagnostic information for administrators: Generating server: AS8PR02MB8519.eurprd02.prod.outlook.com System@successfactors.com Remote server returned '554 5.2. Dec 1, 2024, 12:55 PM tshingombe fiston Dec 1, 2024, 12:55 PM electricity consumption.[30] tshingombe fiston Sat, Nov 30, 2024, 5:38 PM to regionArevenue, regionBrevenue, tenderadvicecentre, estimations, wmcqueries, Mediadesk, SARS, me City Power is responsible for providing electrical services to property owners in the City of Johannesburg that are not serviced by Eskom. To determine if you are a City Power customer you can check your existing City of Johannesburg invoice and see if you are being billed for electricity. If you don't have an invoice or if you don't have a service connection you can check the township list, it will indicate in whose supply area the property is. The service connections we provide are divided into two categories namely Small Power Users (SPU) and Larger Power Users (LPU). A Small Power User is defined as a user who has an electrical service connection no greater than 56 kVA (3 phase, 80 ampere). In general most households would have this type of service connection. A Large Power User is defined as a user who has an electrical service connection larger than 56 kVA. In general these type of connections are used for medium and large commercial or industrial consumers as well as high density residential developments. We want to provide property owners with the services they require in as short time as possible. To assist with this, the information and documents required to make an application for electrical services are detailed in the documents on this webpage. 1. Apply to convert a SPU from postpaid to pre-paid billing 2. Apply for a new prepaid or postpaid SPU connection (this guide also covers application for alterations to a small power user connection) 3. Apply for a new LPU connection (the guide also covers applications for alterations to a large power user connection) The application form that needs to be submitted when making an ☐ new feed updates notifications ☐Sales Nav City Power Johannesburg Visit website ☐Home ☐About ☐Posts ☐Jobs ☐People ☐Insights City Power Johannesburg Customer-focused energy services company, operating and maintaining the Johannesburg's electricity distribution network. Electric Power Transmission, Control, and Distribution Johannesburg, Gauteng 1K followers 1K-5K employees Visit website ☐Home ☐About ☐Posts ☐Jobs ☐People ☐Insights City Power Johannesburg 1,034 followers See a collection of active or past ads by City Power Johannesburg. View ad library Feed post number 1 City Power JohannesburgCity Power Johannesburg 1,034 followers1,034 followers 2w • 2 weeks ago City Power's Green Energy Future: Solar Microgrids Empower Communities hashtag#CityPowerServices hashtag#CityPowerEnergyPlan City Power's Green Energy Future: Solar Microgrids Empower Communities City Power Johannesburg By Kgagodi MadibaCity Power is taking significant strides to reduce greenhouse gas emissions and bring sustainable energy solutions to Johannesburg co ☐ ☐ Home ☐ ☐ My Network ☐ ☐ Jobs ☐ 1 1 new message notification ☐ Messaging ☐ 25 25 new notifications ☐ Notifications ☐ ☐ ☐ ☐ ☐ application can also be found with the downloadable documents on the below table. On Sat, Nov 30, 2024 at 5:11 PM tshingombe fiston wrote: https://www.sars.gov.za/businesses-and-employers/trusts/registering-as-a-trust/register-a-trust-supporting-documents/ 4 Attachments • Scanned by Gmail tshingombe fiston On Sat, Nov 30, 2024 at 5:38 PM tshingombe fiston wrote: City Power is responsible for providing electrical services to property ow Dec 1, 2024, 12:17 PM postmaster@sap.onmicrosoft.com Delivery has failed to these recipients or groups: SARS Human Capital and Development (System@successfactors.com) The recipient's mailbox is full and can't acce Dec 1, 2024, 12:19 PM tshingombe fiston Turn on more accessible mode Skip Ribbon Commands Skip to main content Webmail Contact Us Sign Out - HomeCurrently selected - Our Company - Company Information Dec 1, 2024, 12:52 PM Mail Delivery Subsystem Message blocked Your message to sarb-graduaterecruit@resbank.co.za has been blocked. See technical details below for more information. LEARN MORE This link will Dec 1, 2024, 12:53 PM Mail Delivery Subsystem Message blocked Your message to admni@resbank.co.za has been blocked. See technical details below for more information. LEARN MORE This link will take you to a Dec 1, 2024, 12:53 PM Mail Delivery Subsystem Address not found Your message wasn't delivered to customerservice@eskom.co.za because the address couldn't be found, or is unable to receive mail. LEARN MORE T Dec 1, 2024, 12:53 PM Mail Delivery Subsystem Address not found Your message wasn't delivered to GITServiceDesk@eskom.co.za because the address couldn't be found, or is unable to receive mail. LEARN MORE Th Dec 1, 2024, 12:53 PM postmaster@dmre.gov.za Your message to examweb@dmr.gov.za couldn't be delivered. The group examweb only accepts messages from people in its organization or on its allowed senders list Dec 1, 2024, 12:53 PM postmaster@sap.onmicrosoft.com Diagnostic information for administrators: Generating server: AS8PR02MB8519.eurprd02.prod.outlook.com System@successfactors.com Remote server returned '554 5.2. Dec 1, 2024, 12:55 PM tshingombe fiston Dec 1, 2024, 12:55 PM to SARS, regionArevenue, regionBrevenue, tenderadvicecentre, estimations, wmcqueries, Mediadesk, customerservice, Mobility, DET, keith.bowen, SARB, admni, DSI-Notification, DMR, Advisoryservice, sarb-graduaterecruit, GITServiceDesk, csd, me Turn on more accessible mode Skip Ribbon Commands Skip to main content [☐A A A ☐Contact Us ☐Webmail ☐Job Opportunities ☐My Details Sign Out Top Link Bar /☐ oOur Company oAbout Electricity oWhat we're doing oIDM oCustomer Care oCareers oTenders My Applications My Applications Position Created Engineering Prof Civil Auxiliary Plant (Generation) Lethabo Power Station 2024/04/24 12:59 PM Engineers in Training X09_ Electrical HC x2_ C and I x3_Mechanical or Chemical x3_Industrial Engineering x1 (Gx Kusile Powe 2024/05/19 09:36 AM Senior-Clerk-General-Administration-(Dx)-CPM-Aliwal-North 2024/05/19 09:38 AM Engineer Prof Engineering (NP)Distribution Bloemfontein 2024/05/19 09:38 AM Middle Manager Nuclear Safety and Assurance (ISED) X1 (Generation) Koeberg NPS 2024/05/19 09:39 AM Senior Advisor Education and Training (ETD) x1 (Engineering and Maintenance) Peaking 2024/05/29 02:40 PM Technical Official PPM Mechanical X2 (Distribution) EAL Midrand 2024/09/01 01:27 PM 1 Learning-Programme-Engineer-in-Training-x-2,-Generation,-Megawatt-Park 2024/09/01 01:29 PM Learning Programme Engineer in Trainng x17 GX Matla Power Station 2024/09/01 01:29 PM Manager Site Outage Execution, Generation, Tutuka Power Station 2024/09/01 01:30 PM Re Advert Snr Technologist Electrical Engineering Substation x2 (National Transmission Company South Africa) MWP Sunninghill 2024/09/01 01:31 PM Re Advert Snr Technologist Electrical Engineering Substation x2 (National Transmission Company South Africa) MWP Sunninghill 2024/09/01 01:31 PM Senior Technician Chemistry x2 (Technical Support and Oils Micro) (Generation) Koeberg NPS 2024/09/01 01:32 PM Officer Safety Health Environment X1 Generation Medupi Power Station 2024/09/01 01:33 PM Learning Programme Outages x1 - Graduate in Training , Generation, Megawatt Park and Witbank 2024/09/01 01:34 PM Learning Programme - Graduate in Training-Quantity Surveyor, Generation, Megawatt Park 2024/09/01 01:35 PM Senior Advisor Supplier Development, Localisation and Industrialisation x2, Generation, Megawatt Park and Tutuka Power Stat 2024/09/01 01:35 PM Graduate-in-Training (Finance) 2024/09/01 01:37 PM Re Advert Snr Draughtsperson Draughting Electrical Substation Engineering x3 NTCSA MWP 2024/09/01 01:38 PM Technician-in-Training x2 (1xC+I and 1+Mech) 2024/09/01 01:39 PM Snr. Supervisor Tech Instrument x 2 (Generation) Tutuka Power Station 2024/09/01 01:39 PM Engineer-in-Training-Control and Instrumentation AND-Auxiliary and Ancillary-(Peaking Durbanville)-X2 2024/09/01 01:40 PM Re Advert Senior Technician Configuration X1 (Generation) Medupi Power Station 2024/09/01 01:42 PM Engineer Prof Eng Quality of Supply (National Transmission Company South Africa) Newcastle 2024/09/01 01:43 PM Learning Programme - Graduate in Training x1, Generation, Megawatt Park 2024/09/01 01:44 PM Learning-Programme -Graduate-in-Training-x3,-Generation,-1Megawatt-Park 2024/09/01 01:45 PM Learning Programme-Graduate in Training x 3, Generation, Megawatt Park 2024/09/01 01:46 PM Learning Programme-Graduate in Training x 2, Generation, Megawatt Park 2024/09/01 01:47 PM Senior Supervisor Technical Projects (National Transmission Company South Africa)Northwest and Limpopo 2024/09/01 01:49 PM Snr-Advisor-Applications-Support-(Group-IT-DIVISION)-Megawatt-Park 2024/09/01 01:50 PM 1 - 30 Follows us on /☐oOur Company /☐Company Information /☐Leadership /☐Investors ☐Sustainable Development /☐CSI ☐Media Room /☐PAIA /☐Eskom Heritage /☐Photo Gallery /☐Video Clips oAbout Electricity /☐Electricity Tips /☐Electricity Technologies ☐Eskom Power Series /☐Renewable Energy /☐Facts & Figures /☐Visitor Centers /☐MODIS Fire Alerts oWhat we're doing /☐Electricity Generation ☐New Build /☐Transmission Development Plan /☐Ancillary Services /☐CCCA Report /☐Supply Status /☐Info Site For IPPs ☐School Of Welding /☐Eskom initiatives oIDM /☐Integrated Demand Management /☐Energy Advice /☐Eskom Solar Water Heating Programme /☐Measurement Verification oCustomer Care ☐CS Online /☐Tariffs And Charges /☐MYPD3 /☐Customer Service Information /☐Subscribe /☐CS Mobile /☐Customer Feedback /☐Customer Care Video Clips ☐IDM oCareers /☐Vacancies oTenders ☐Eskom Purchasing Policies ☐Tender Process ☐Whats Out To Tender ☐Supplier Registration /☐Insurance Policies Procedures /☐BBBEE Certificate Copyright © 2024 Eskom Holdings SOC Ltd Reg No 2002/15527/30. All rights reserved. | Terms of use Webmail | Media Info | Sustainability | Job Opportunities | Contact Us Original text Rate this translation Your feedback will be used to help improve Google Translate ... [Message clipped] View entire message Mail Delivery Subsystem Message blocked Your message to sarb-graduaterecruit@resbank.co.za has been blocked. See technical details below for more information. LEARN MORE This link will Dec 1, 2024, 12:55 PM Mail Delivery Subsystem Message blocked Your message to admni@resbank.co.za has been blocked. See technical details below for more information. LEARN MORE This link will take you to a Dec 1, 2024, 12:55 PM Mail Delivery Subsystem Address not found Your message wasn't delivered to customerservice@eskom.co.za because the address couldn't be found, or is unable to receive mail. LEARN MORE T Dec 1, 2024, 12:55 PM Mail Delivery Subsystem Address not found Your message wasn't delivered to GITServiceDesk@eskom.co.za because the address couldn't be found, or is unable to receive mail. LEARN MORE Th Dec 1, 2024, 12:55 PM postmaster@sap.onmicrosoft.com Diagnostic information for administrators: Generating server: AS1PR02MB7918.eurprd02.prod.outlook.com System@successfactors.com Remote server returned '554 5.2. Dec 1, 2024, 12:56 PM postmaster@dmre.gov.za Your message to examweb@dmr.gov.za couldn't be delivered. The group examweb only accepts messages from people in its organization or on its allowed senders list Dec 1, 2024, 12:56 PM RegionB Revenue Dec 2, 2024, 10:26 AM to SARS, RegionA, RegionB, Estimations, WMCQUERIES, Media, me On Sat, Nov 30, 2024 at 5:38 PM tshingombe fiston wrote: City Power is responsible for providing electrical services to property owners in the City of Johannesburg that are not serviced by Eskom. To determine if you are a City Power customer you can check your existing City of Johannesburg invoice and see if you are being billed for electricity. If you don't have an invoice or if you don't have a service connection you can check the township list, it will indicate in whose supply area the property is. The service connections we provide are divided into two categories namely Small Power Users (SPU) and Larger Power Users (LPU). A Small Power User is defined as a user who has an electrical service connection no greater than 56 kVA (3 phase, 80 ampere). In general most households would have this type of service connection. A Large Power User is defined as a user who has an electrical service connection larger than 56 kVA. In general these type of connections are used for medium and large commercial or industrial consumers as well as high density residential developments. We want to provide property owners with the services they require in as short time as possible. To assist with this, the information and documents required to make an application for electrical services are detailed in the documents on this webpage. 1. Apply to convert a SPU from postpaid to pre-paid billing 2. Apply for a new prepaid or postpaid SPU connection (this guide also covers application for alterations to a small power user connection) 3. Apply for a new LPU connection (the guide also covers applications for alterations to a large power user connection) The application form that needs to be submitted when making an [ ] ☐ new feed updates notifications ☐Sales Nav City Power Johannesburg Visit website ☐Home ☐About ☐Posts ☐Jobs ☐People ☐Insights City Power Johannesburg Customer-focused energy services company, operating and maintaining the Johannesburg's electricity distribution network. Electric Power Transmission, Control, and Distribution Johannesburg, Gauteng 1K followers 1K-5K employees Visit website ☐Home ☐About ☐Posts ☐Jobs ☐People ☐Insights City Power Johannesburg 1,034 followers See a collection of active or past ads by City Power Johannesburg. View ad library Feed post number 1 City Power JohannesburgCity Power Johannesburg 1,034 followers1,034 followers 2w • 2 weeks ago City Power's Green Energy Future: Solar Microgrids Empower Communities hashtag#CityPowerServices hashtag#CityPowerEnergyPlan City Power's Green Energy Future: Solar Microgrids Empower Communities City Power Johannesburg By Kgagodi MadibaCity Power is taking significant strides to reduce greenhouse gas emissions and bring sustainable energy solutions to Johannesburg co ☐ ☐ Home ☐ ☐ My Network ☐ ☐ Jobs ☐ 1 1 new message notification ☐ Messaging ☐ 25 25 new notifications ☐ Notifications ☐ ☐ ☐ ☐ ☐ application can also be found with the downloadable documents on the below table. On Sat, Nov 30, 2024 at 5:11 PM tshingombe fiston wrote: https://www.sars.gov.za/businesses-and-employers/trusts/registering-as-a-trust-supporting-documents/ Disclaimer The information contained in this communication from the sender is confidential. It is intended solely for use by the recipient and others authorized to receive it. If you are not the recipient, you are hereby notified that any disclosure, copying, distribution or taking action in relation of the contents of this information is strictly prohibited and may be unlawful. This email has been scanned for viruses and malware, and may have been automatically archived by Mimecast Ltd, an innovator in Software as a Service (SaaS) for business. Providing a safer and more useful place for your human generated data. Specializing in; Security, archiving and compliance. To find out more Click Here. tshingombe fiston On Mon, 02 Dec 2024, 10:26 RegionB Revenue, wrote: On Sat, Nov 30, 2024 at 5:38 PM tshingombe fiston Feb 2, 2025, 2:29 PM tshingombe fiston Feb 3, 2025, 11:36 AM to regionArevenue, wmcqueries, Mediadesk, estimations, tenderadvicecentre, RegionB 6 Attachments • Scanned by Gmail RegionB Revenue Dear valued customer, Please provide us with your municipal account number and describe the nature of your query in detail.

Thank you for utilizing the regional Feb 5, 2025, 12:50 PM tshingombe fiston Thanks - municipality city Johannesburg - CDs R169241870 -; Feb 5, 2025, 1:19 PM RegionB Revenue Dear valued customer, Kindly provide a transfer letter The Region B Customer Service Team On Mon, Dec 2, 2024 at 10:26 AM RegionB Revenue <regionBrevenue@joburg Feb 5, 2025, 1:35 PM tshingombe fiston Thank you, will do. Feb 6, 2025, 9:33 AM RegionB Revenue Thanks City Power Johannesburg Visit website Feed post number 1 Feb 7, 2025, 8:58 AM RegionB Revenue Feb 10, 2025, 8:06 AM to me Dear valued customer, Thank you for utilizing the regional email service. Kind Regards, tshingombe fiston You are welcome. Feb 10, 2025, 6:03 PM RegionB Revenue Feb 12, 2025, 10:43 AM (12 days ago) to me Most Welcome tshingombe fiston Feb 23, 2025, 10:28 AM (1 day ago) to RegionB 2 Attachments • Scanned by Gmail tshingombe fiston Feb 23, 2025, 1:18 PM (21 hours ago) to RegionB 6 Attachments • Scanned by Gmail City Power Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia City Power Company type Electric utility Industry Electric power industry Founded January 1, 2001; 24 years ago Headquarters 40 Heronmere Road, Reuven, Johannesburg , South Africa Area served Johannesburg Key people Tshifularo Mashava (CEO) Revenue R 17 billion (2020/21) Total assets R 19.7 billion (2019/20) Number of employees 1750 (2020/21) Website citypower.co.za City Power Johannesburg (or Joburg City Power) is a state owned power utility, wholly owned by the City of Johannesburg. Its responsibilities include buying electricity from power producers and supplying it to the public, and installing and maintaining the electrical infrastructure in the city of Johannesburg. It supplies electricity to 3.2 million people in the Greater Johannesburg Metropolitan Area.[1] History Joburg City Power was established as a separate company from the City of Johannesburg on 1 January 2000. On the 19th December 2001, the National Energy Regulator of South Africa (NERSA), granted City Power a licence to trade. In 2022, it took over the electricity distribution functions from Eskom to Soweto and parts of Johannesburg, including Sandton, Orange Farm, Finetown, Ivory Park and Diepsloot; Eskom was previously responsible for supplying electricity to most parts of Johannesburg.[2][3] Corruption In 2013, a controversial R1.2 billion contract was awarded by the City of Johannesburg to Edison Power, a company owned by Vivian Reddy, a close ally of Jacob Zuma, for smart meters used by City Power customers.[4] Edison Power was initially allocated a R600-million share of an R800-million contract. Subsequently, the contract value was revised to R1.25 billion and Edison Power received the exclusive contract.[4] Load shedding Kelvin Power Station, a coal-fired power station, provides the City Johannesburg 10% of its power. City Power currently obtains 90% of its power from Eskom and 10% from the Kelvin Power Station from which it seeks to move away from.[5] In 2014, it announced that it will remotely switch off geysers "to reduce the impact of load shedding. [6] In 2021, it resolved to be an electricity generator to "reduce over-reliance on Eskom".[7] In 2023, the City of Johannesburg along with City Power aimed to cut load shedding in Johannesburg by 3 stages through the use of smart meters and the recommissioning of two existing open cycle gas turbines. It also sought to secure power on a long-term basis from independent power producers (IPPs).[8] In 2023, City Power said it had to replace more than 390 mini-substations (pole-mounted transformers), at a cost of R200 million which constituted 80% of its budget for the year. The cause of this was load shedding, theft and vandalism.[9][10][11] In September 2023, City Power announced a drive that would replace all meters with smart meters before 24 November 2024. This was due to a limitation in all meters that generate a token ID using the Standard Transfer Specification. This change would also enable City Power to remotely limit electricity usage in households whose usage is higher than normal.[12] From 6 November 2023, City Power took over management of the load shedding schedule from Eskom.[13] From 10 June 2024, City Power implemented its own form of load shedding called load reduction.[14] Electricity procurement In 2023, through grid access it aims to obtain 53MW from customer-embedded rooftop solar generation and 3.7MW from municipal building PV generation, for a total of 60MW.[2] By 2026/27, it hopes to target 480MW (with 200MW coming from households and businesses, 150MW from independent power producers on private and mining land, 50MW from financed rooftop IPP PV programmes, 27MW through municipal building PV generation, 33.5MW from landfill gas generation and solid waste-to-energy, and 20MW from natural gas generation.)[2] In July 2023, the City of Johannesburg introduced wheeling tariffs which charge both independent power producers and City Power customers to allow use of the existing grid infrastructure to supply customers with electricity.[15] In August 2023, City Power secured 92MW from four IPPs: waste-to-energy (20MW), gas-to-power (31MW) and PV solar generation (40.8MW).[16] In April 2024, the 50 MW John Ware Gas Turbine Power Station was recommissioned.[17] Revenue recuperation City Power has endeavoured to collect R8.9 billion owed by businesses and households. It did this by first giving notices of disconnecting the power of delinquent parties, and compelling them to pay. It said it will impose penalties on businesses and residential complexes that have defaulted on their accounts and connected electricity illegally.[18] Businesses The Apartheid Museum was one of the disconnected clients, with it owing R1.8 million.[19] The Gauteng Treasury was another, with it owing over R34 million.[20] In February 2023, some of the disconnected clients were a shopping centre running an illegal connection on its meters and was penalised with a R100 000 fine, the Church of Scientology with R877 000 in arrears, a sports club in Bryanston which owed R2.3 million and the Nigerian consulate which owed R406 000.[18] In October 2023, it announced that it would give government entities Rahima Moosa Mother and Child Hospital and the Helen Joseph Hospital 14 days to settle a combined debt of R32 million.[21] In June 2024, Eskom issued an ultimatum to the City of Johannesburg (COJ) and City Power for electricity non payment. Joburg owes Eskom R3.4 billion.[22] According to the record, last payments were made in October 2023.[23] The Johannesburg High Court instructed the City of Johannesburg and City Power to immediately pay the first billion of their defaulting amount.[24] Residential customers In September 2023, City Power conducted a disconnection drive of non-paying customers in Naturena and the Lenasia Service Delivery Centre (SDC) in an attempt to collect revenue; the Lenasia SDC which includes surrounding areas like Eldorado Park, Ennerdale, Zakariyya Park and Lehae, owed R 1.3 billion.[25] The City of Johannesburg, through City Power meters, began subtracting municipal debt owed by businesses and residential customers from prepaid electricity purchases.[26] From July 2024, City Power began deducting a R230 service charge from its prepaid customers; along with an increase in the electricity price per KWh, this saw a 23.15% increase from the previous year for all customers including indigent customers (6 to 12 times the inflation rate).[27][28] Photograph your local culture, help Wikipedia and win! Contents (Top) Organization o Power transactions o Executive compensation Oversight Alternative energy promotion Nuclear energy Customer expectations See also References Electric utility Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia An electric utility, or a power company, is a company in the electric power industry (often a public utility) that engages in electricity generation and distribution of electricity for sale generally in a regulated market.[1] The electrical utility industry is a major provider of energy in most countries. Electric utilities include investor owned, publicly owned, cooperatives, and nationalized entities. They may be engaged in all or only some aspects of the industry. Electricity markets are also considered electric utilities—these entities buy and sell electricity, acting as brokers, but usually do not own or operate generation, transmission, or distribution facilities. Utilities are regulated by local and national authorities. Electric utilities are facing increasing demands[2] including aging infrastructure, reliability, and regulation. In 2009, the French company EDF was the world's largest producer of electricity.[3] Organization Power transactions An electric power system is a group of generation, transmission, distribution, communication, and other facilities that are physically connected.[4] The flow of electricity within the system is maintained and controlled by dispatch centers which can buy and sell electricity based on system requirements. Executive compensation The examples and perspective in this article may not represent a worldwide view of the subject. You may improve this article, discuss the issue on the talk page, or create a new article, as appropriate. (February 2016) (Learn how and when to remove this message) The executive compensation received by the executives in utility companies often receives the most scrutiny in the review of operating expenses. Just as regulated utilities and their governing bodies struggle to maintain a balance between keeping consumer costs reasonable and being profitable enough to attract investors, they must also compete with private companies for talented executives and then be able to retain those executives.[5] Regulated companies are less likely to use incentive-based remuneration in addition to base salaries. Executives in regulated electric utilities are less likely to be paid for their performance in bonuses or stock options.[5] They are less likely to approve compensation policies that include incentive-based pay.[5] The compensation for electric utility executives will be the lowest in regulated utilities that have an unfavorable regulatory environment. These companies have more political constraints than those in a favorable regulatory environment and are less likely to have a positive response to requests for rate increases.[6] Just as increased constraints from regulation drive compensation down for executives in electric utilities, deregulation has been shown to increase remuneration. The need to encourage risk-taking behavior in seeking new investment opportunities while keeping costs under control requires deregulated companies to offer performance-based incentives to their executives. It has been found that increased compensation is also more likely to attract executives experienced in working in competitive environments.[7] In the United States, the Energy Policy Act of 1992 removed previous barriers to wholesale competition in the electric utility industry. Currently 24 states allow for deregulated electric utilities: Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, Texas, Virginia, Arizona, Arkansas, California, Connecticut, Delaware, Illinois, Maine, Maryland, Massachusetts, Michigan, Montana, New Hampshire, New Jersey, New Mexico, New York, and Washington D.C.[8] As electric utility monopolies have been increasingly broken up into deregulated businesses, executive compensation has risen; particularly incentive compensation.[9] Oversight Oversight is typically carried out at the national level, however it varies depending on financial support and external influences.[10] There is no existence of any influential international energy oversight organization. There does exist a World Energy Council, but its mission is mostly to advise and share new information.[11] It does not hold any kind of legislative or executive power. Alternative energy promotion Alternative energy has become more and more prevalent in recent times and as it is inherently independent of more traditional sources of energy, the market seems to have a very different structure. In the United States, to promote the production and development of alternative energies, there are many subsidies, rewards, and incentives that encourage companies to take up the challenge themselves. There is precedent for such a system working in countries like Nicaragua. In 2005, Nicaragua gave renewable energy companies tax and duty exemptions, which spurred a great deal of private investment.[12] The success in Nicaragua may not be an easily replicated situation however. The movement was known as Energiewende and it is generally considered a failure for many reasons.[13] A primary reason was that it was improperly timed and was proposed during a period in which their energy economy was under more competition. Globally, the transition of electric utilities to renewables remains slow, hindered by concurrent continued investment in the expansion of fossil fuel capacity.[14] Nuclear energy Nuclear energy may be classified as a green source depending on the country. Although there used to be much more privatization in this energy sector, after the 2011 Fukushima district nuclear power plant disaster in Japan, there has been a move away from nuclear energy itself, especially for privately owned nuclear power plants.[citation needed] The criticism being that privatization of companies tend to have the companies themselves cutting corners and costs for profits which has proven to be disastrous in the worst-case scenarios. This placed a strain on many other countries as many foreign governments felt pressured to close nuclear power plants in response to public concerns.[13] Nuclear energy however still holds a major part in many communities around the world. Customer expectations Utilities have found that it isn't simple to meet the unique needs of individual customers, whether residential, corporate, industrial, government, military, or otherwise. Customers in the twenty-first century have new and urgent expectations that demand a transformation of the electric grid. They want a system that gives them new tools, better data to help manage energy usage, advanced protections against cyberattacks, and a system that minimizes outage times and quickens power restoration.[15] See also Electrical grid Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia (Redirected from Grid access) For other uses, see Grid (disambiguation). "Power grid" redirects here. For the board game, see Power Grid. Diagram of an electrical grid (generation system in red, transmission system in blue, distribution system in green) An electrical grid (or electricity network) is an interconnected network for electricity delivery from producers to consumers. Electrical grids consist of power stations, electrical substations to step voltage up or down, electric power transmission to carry power over long distances, and finally electric power distribution to customers. In that last step, voltage is stepped down again to the required service voltage. Power stations are typically built close to energy sources and far from densely populated areas. Electrical grids vary in size and can cover whole countries or continents. From small to large there are microgrids, wide area synchronous grids, and super grids. The combined transmission and distribution network is part of electricity delivery, known as the power grid. Grids are nearly always synchronous, meaning all distribution areas operate with three phase alternating current (AC) frequencies synchronized (so that voltage swings occur at almost the same time). This allows transmission of AC power throughout the area, connecting the electricity generators with consumers. Grids can enable more efficient electricity markets. Although electrical grids are widespread, as of 2016, 1.4 billion people worldwide were not connected to an electricity grid.[1] As electrification increases, the number of people with access to grid electricity is growing. About 840 million people (mostly in Africa), which is ca. 11% of the World's population, had no access to grid electricity in 2017, down from 1.2 billion in 2010.[2] Electrical grids can be prone to malicious intrusion or attack; thus, there is a need for electric grid security. Also as electric grids modernize and introduce computer technology, cyber threats start to become a security risk.[3] Particular concerns relate to the more complex computer systems needed to manage grids.[4] Types (grouped by size) Part of a series on Power engineering Electric power conversion Voltage converter Electric power conversion HVDC converter station AC-to-AC converter DC-to-DC converter Rectifier Inverter Electric power infrastructure Electric power system Power station Electrical grid Interconnector Demand response Electric power systems components Ring main unit Grid-tie inverter Energy storage Busbar Bus duct Recloser Protective relay v t e Microgrid Main article: Microgrid A microgrid is a local grid that is usually part of the regional wide-area synchronous grid, but which can disconnect and operate autonomously.[5] It might do this in times when the main grid is affected by outages. This is known as islanding, and it might run indefinitely on its own resources. Compared to larger grids, microgrids typically use a lower voltage distribution network and distributed generators.[6] Microgrids may not only be more resilient, but may be cheaper to implement in isolated areas. A design goal is that a local area produces all of the energy it uses.[5] Example implementations include: Hajjah and Lahj, Yemen: community-owned solar microgrids.[7] Île d'Yeu pilot program: sixty-four solar panels with a peak capacity of 23.7 kW on five houses and a battery with a storage capacity of 15 kWh.[8][9] Les Anglais, Haiti:[10] includes energy theft detection.[11] Mpeketoni, Kenya: a community-based diesel-powered micro-grid system.[12] Stone Edge Farm Winery: micro-turbine, fuel-cell, multiple battery, hydrogen electrolyzer, and PV enabled winery in Sonoma, California.[13][14] Wide area synchronous grid Main article: Wide area synchronous grid A wide area synchronous grid (also called an "interconnection" in North America) is an electrical grid at a regional scale or greater that operates at a synchronized frequency and is electrically tied together during normal system conditions. For example, there are four major interconnections in North America (the Western Interconnection, the Eastern Interconnection, the Quebec Interconnection and the Texas Interconnection). In Europe, one large grid connects most of Western Europe. These are also known as synchronous zones, the largest of which is the synchronous grid of Continental Europe (ENTSO-E) with 667 gigawatts (GW) of generation, and the widest region served being that of the IPS/UPS system serving countries of the former Soviet Union. Synchronous grids with ample capacity facilitate electricity market trading across wide areas. In the ENTSO-E in 2008, over 350,000 megawatt hours were sold per day on the European Energy Exchange (EEX).[15] Each of the interconnects in North America are run at a nominal 60 Hz, while those of Europe run at 50 Hz. Neighbouring interconnections with the same frequency and standards can be synchronized and directly connected to form a larger interconnection, or they may share power without synchronization via high-voltage direct current power transmission lines (DC ties), or with variable-frequency transformers (VFTs), which permit a controlled flow of energy while also functionally isolating the independent AC frequencies of each side. The benefits of synchronous zones include pooling of generation, resulting in lower generation costs; pooling of load, resulting in significant equalizing effects; common provisioning of reserves, resulting in cheaper primary and secondary reserve power costs; opening of the market, resulting in possibility of long-term contracts and short term power exchanges; and mutual assistance in the event of disturbances.[16] One disadvantage of a wide-area synchronous grid is that problems in one part can have repercussions across the whole grid. For example, in 2018, Kosovo used more power than it generated due to a dispute with Serbia, leading to the phase across the whole synchronous grid of Continental Europe lagging behind what it should have been. The frequency dropped to 49.996 Hz. This caused certain kinds of clocks to become six minutes slow.[17] The synchronous grids of Europe The two major and three minor interconnections of North America Major WASGs around the world Super grid Main article: Super grid One conceptual plan of a super grid linking renewable sources across North Africa, the Middle East and Europe. (DESERTEC)[18] A super grid or supergrid is a wide-area transmission network that is intended to make possible the trade of high volumes of electricity across great distances. It is sometimes also referred to as a mega grid. Super grids can support a global energy transition by smoothing local fluctuations of wind energy and solar energy. In this context, they are considered as a key technology to mitigate global warming. Super grids typically use high-voltage direct current (HVDC) to transmit electricity long distances. The latest generation of HVDC power lines can transmit energy with losses of only 1.6% per 1000 km.[19] Electric utilities between regions are many times interconnected for improved economy and reliability. Electrical interconnectors allow for economies of scale, allowing energy to be purchased from large, efficient sources. Utilities can draw power from generator reserves from a different region to ensure continuing, reliable power and diversify their loads. Interconnection also allows regions to have access to cheap bulk energy by receiving power from different sources. For example, one region may be producing cheap hydro power during high water seasons, but in low water seasons, another area may be producing cheaper power through wind, allowing both regions to access cheaper energy sources from one another during different times of the year. Neighboring utilities also help others to maintain the overall system frequency and also help manage tie transfers between utility regions.[20] Electricity Interconnection Level (EIL) of a grid is the ratio of the total interconnector power to the grid divided by the installed production capacity of the grid. Within the EU, it has set a target of national grids reaching 10% by 2020, and 15% by 2030.[21] Components Generation Main article: Electricity generation Turbo generator Electricity generation is the process of generating electric power at power stations. This is done ultimately from sources of primary energy typically with electromechanical generators driven by heat engines from fossil, nuclear, and geothermal sources, or driven by the kinetic energy of water or wind. Other power sources are photovoltaics driven by solar insolation, and grid batteries.[nb 1] The sum of the power outputs of generators on the grid is the production of the grid, typically measured in gigawatts (GW). Transmission Main article: Electric power transmission 500 kV Three-phase electric power Transmission Lines at Grand Coulee Dam; four circuits are shown; two additional circuits are obscured by trees on the right; the entire 7079 MW generation capacity of the dam is accommodated by these six circuits.Network diagram of a high voltage transmission system, showing the interconnection between the different voltage levels. This diagram depicts the electrical structure[22] of the network, rather than its physical geography. Electric power transmission is the bulk movement of electrical energy from a generating site, via a web of interconnected lines, to an electrical substation, from which is connected to the distribution system. This networked system of connections is distinct from the local wiring between high-voltage substations and customers. Transmission networks are complex with redundant pathways. Redundancy allows line failures to occur and power is simply rerouted while repairs are done. Because the power is often generated far from where it is consumed, the transmission system can cover great distances. For a given amount of power, transmission efficiency is greater at higher voltages and lower currents. Therefore, voltages are stepped up at the generating station, and stepped down at local substations for distribution to customers. Most transmission is three-phase. Three-phase, compared to single-phase, can deliver much more power for a given amount of wire, since the neutral and ground wires are shared.[23] Further, three-phase generators and motors are more efficient than their single-phase counterparts. However, for conventional conductors one of the main losses are resistive losses which are a square law on current, and depend on distance. High voltage AC transmission lines can lose 1-4% per hundred miles.[24] However, high-voltage direct current can have half the losses of AC. Over very long distances, these efficiencies can offset the additional cost of the required AC/DC converter stations at each end. Substations Main article: Electrical substation Substations may perform many different functions but usually transform voltage from low to high (step up) and from high to low (step down). Between the generator and the final consumer, the voltage may be transformed several times.[25] The three main types of substations, by function, are:[26] Step-up substation: these use transformers to raise the voltage coming from the generators and power plants so that power can be transmitted long distances more efficiently, with smaller currents. Step-down substation: these transformers lower the voltage coming from the transmission lines which can be used in industry or sent to a distribution substation. Distribution substation: these transform the voltage lower again for the distribution to end users. Aside from transformers, other major components or functions of substations include: Circuit breakers: used to automatically break a circuit and isolate a fault in the system.[27] Switches: to control the flow of electricity, and isolate equipment.[28] The substation busbar: typically a set of three conductors, one for each phase of current. The substation is organized around the buses, and they are connected to incoming lines, transformers, protection equipment, switches, and the outgoing lines.[27] Lightning arresters Capacitors for power factor correction Synchronous condensers for power factor correction and grid stability Electric power distribution Main article: Electric power distribution General layout of electricity grids. Voltages and depictions of electrical lines are typical for Germany and other European systems. Distribution is the final stage in the delivery of power; it carries electricity from the transmission system to individual consumers. Substations connect to the transmission system and lower the transmission voltage to medium voltage ranging between 2 kV and 35 kV. But the voltage levels varies very much between different countries, in Sweden medium voltage are normally 10 kV between 20 kV.[29] Primary distribution lines carry this medium voltage power to distribution transformers located near the customer's premises. Distribution transformers again lower the voltage to the utilization voltage. Customers demanding a much larger amount of power may be connected directly to the primary distribution level or the subtransmission level.[30] Distribution networks are divided into two types, radial or network.[31] In cities and towns of North America, the grid tends to follow the classic radially fed design. A substation receives its power from the transmission network, the power is stepped down with a transformer and sent to a bus from which feeders fan out in all directions across the countryside. These feeders carry three-phase power, and tend to follow the major streets near the substation. As the distance from the substation grows, the fanout continues as smaller laterals spread out to cover areas missed by the feeders. This tree-like structure grows outward from the substation, but for reliability reasons, usually contains at least one unused backup connection to a nearby substation. This connection can be enabled in case of an emergency, so that a portion of a substation's service territory can be alternatively fed by another substation. Storage Main article: Grid energy storage Energy from fossil or nuclear power plants and renewable sources is stored for use by customers. Simplified grid energy flow over the course of a day Grid energy storage (also called large-scale energy storage) is a collection of methods used for energy storage on a large scale within an electrical power grid. Electrical energy is stored during times when electricity is plentiful and inexpensive (especially from intermittent power sources such as renewable electricity from wind power, tidal power and solar power) or when demand is low, and later power is generated when demand is high, and electricity prices tend to be higher. As of 2020, the largest form of grid energy storage is dammed hydroelectricity, with both conventional hydroelectric generation as well as pumped storage hydroelectricity. Developments in battery storage have enabled commercially viable projects to store energy during peak production and release during peak demand, and for use when production unexpectedly falls giving time for slower responding resources to be brought online. Two alternatives to grid storage are the use of peaking power plants to fill in supply gaps and demand response to shift load to other times. Functionalities Demand The demand, or load on an electrical grid is the total electrical power being removed by the users of the grid. The graph of the demand over time is called the demand curve. Baseload is the minimum load on the grid over any given period, peak demand is the maximum load. Historically, baseload was commonly met by equipment that was relatively cheap to run, that ran continuously for weeks or months at a time, but globally this is becoming less common. The extra peak demand requirements are sometimes produced by expensive peaking plants that are generators optimised to come on-line quickly but these too are becoming less common. However, if the demand of electricity exceed the capacity of a local power grid, it will cause safety issue like burning out.[32] Voltage Grids are designed to supply electricity to their customers at largely constant voltages. This has to be achieved with varying demand, variable reactive loads, and even nonlinear loads, with electricity provided by generators and distribution and transmission equipment that are not perfectly reliable.[33] Often grids use tap changers on transformers near to the consumers to adjust the voltage and keep it within specification. Frequency Main article: Utility frequency In a synchronous grid all the generators must run at the same frequency, and must stay very nearly in phase with each other and the grid. Generation and consumption must be balanced across the entire grid, because energy is consumed as it is produced. For rotating generators, a local governor regulates the driving torque, maintaining almost constant rotation speed as loading changes. Energy is stored in the immediate short term by the rotational kinetic energy of the generators. Although the speed is kept largely constant, small deviations from the nominal system frequency are very important in regulating individual generators and are used as a way of assessing the equilibrium of the grid as a whole. When the grid is lightly loaded the grid frequency runs above the nominal frequency, and this is taken as an indication by Automatic Generation Control systems across the network that generators should reduce their output. Conversely, when the grid is heavily loaded, the frequency naturally slows, and governors adjust their generators so that more power is output (droop speed control). When generators have identical droop speed control settings it ensures that multiple parallel generators with the same settings share load in proportion to their rating. In addition, there's often central control, which can change the parameters of the AGC systems over timescales of a minute or longer to further adjust the regional network flows and the operating frequency of the grid. For timekeeping purposes, the nominal frequency will be allowed to vary in the short term, but is adjusted to prevent line-operated clocks from gaining or losing significant time over the course of a whole 24 hour period. An entire synchronous grid runs at the same frequency, neighbouring grids would not be synchronised even if they run at the same nominal frequency. High-voltage direct current lines or variable-frequency transformers can be used to connect two alternating current interconnection networks which are not synchronized with each other. This provides the benefit of interconnection without the need to synchronize an even wider area. For example, compare the wide area synchronous grid map of Europe with the map of HVDC lines. Capacity and firm capacity The sum of the maximum power outputs (nameplate capacity) of the generators attached to an electrical grid might be considered to be the capacity of the grid. However, in practice, they are never run flat out simultaneously. Typically, some generators are kept running at lower output powers (spinning reserve) to deal with failures as well as variation in demand. In addition generators can be off-line for maintenance or other reasons, such as availability of energy inputs (fuel, water, wind, sun etc.) or pollution constraints. Firm capacity is the maximum power output on a grid that is immediately available over a given time period, and is a far more useful figure. Production Most grid codes specify that the load is shared between the generators in merit order according to their marginal cost (i.e. cheapest first) and sometimes their environmental impact. Thus cheap electricity providers tend to be run flat out almost all the time, and the more expensive producers are only run when necessary. Failures and issues Failures are usually associated with generators or power transmission lines tripping circuit breakers due to faults leading to a loss of generation capacity for customers, or excess demand. This will often cause the frequency to reduce, and the remaining generators will react and together attempt to stabilize above the minimum. If that is not possible then a number of scenarios can occur. A large failure in one part of the grid — unless quickly compensated for — can cause current to re-route itself to flow from the remaining generators to consumers over transmission lines of insufficient capacity, causing further failures. One downside to a widely connected grid is thus the possibility of cascading failure and widespread power outage. A central authority is usually designated to facilitate communication and develop protocols to maintain a stable grid. For example, the North American Electric Reliability Corporation gained binding powers in the United States in 2006, and has advisory powers in the applicable parts of Canada and Mexico. The U.S. government has also designated National Interest Electric Transmission Corridors, where it believes transmission bottlenecks have developed. Brownout Main article: Brownout (electricity) A brownout near Tokyo Tower in Tokyo, Japan A brownout is an intentional or unintentional drop in voltage in an electrical power supply system. Intentional brownouts are used for load reduction in an emergency.[34] The reduction lasts for minutes or hours, as opposed to short-term voltage sag (or dip). The term brownout comes from the dimming experienced by incandescent lighting when the voltage sags. A voltage reduction may be an effect of disruption of an electrical grid, or may occasionally be imposed in an effort to reduce load and prevent a power outage, known as a blackout.[35] Blackout Main article: Power outage A power outage (also called a power cut, a power out, a power blackout, power failure or a blackout) is a loss of the electric power to a particular area. Power failures can be caused by faults at power stations, damage to electric transmission lines, substations or other parts of the distribution system, a short circuit, cascading failure, fuse or circuit breaker operation, and human error. Power failures are particularly critical at sites where the environment and public safety are at risk. Institutions such as hospitals, sewage treatment plants, mines, shelters and the like will usually have backup power sources such as standby generators, which will automatically start up when electrical power is lost. Other critical systems, such as telecommunication, are also required to have emergency power. The battery room of a telephone exchange usually has arrays of lead–acid batteries for backup and also a socket for connecting a generator during extended periods of outage. Load shedding Main article: Demand response Electrical generation and transmission systems may not always meet peak demand requirements— the greatest amount of electricity required by all utility customers within a given region. In these situations, overall demand must be lowered, either by turning off service to some devices or cutting back the supply voltage (brownouts), in order to prevent uncontrolled service disruptions such as power outages (widespread blackouts) or equipment damage. Utilities may impose load shedding on service areas via targeted blackouts, rolling blackouts or by agreements with specific high-use industrial consumers to turn off equipment at times of system-wide peak demand. Black start Main article: Black start Toronto during the Northeast blackout of 2003, which required black-starting of generating stations. A black start is the process of restoring an electric power station or a part of an electric grid to operation without relying on the external electric power transmission network to recover from a total or partial shutdown.[36] Normally, the electric power used within the plant is provided from the station's own generators. If all of the plant's main generators are shut down, station service power is provided by drawing power from the grid through the plant's transmission line. However, during a wide-area outage, off-site power from the grid is not available. In the absence of grid power, a so-called black start needs to be performed to bootstrap the power grid into operation. To provide a black start, some power stations have small diesel generators, normally called the black start diesel generator (BSDG), which can be used to start larger generators (of several megawatts capacity), which in turn can be used to start the main power station generators. Generating plants using steam turbines require station service power of up to 10% of their capacity for boiler feedwater pumps, boiler forced-draft combustion air blowers, and for fuel preparation. It is uneconomical to provide such a large standby capacity at each station, so black-start power must be provided over designated tie lines from another station. Often hydroelectric power plants are designated as the black-start sources to restore network interconnections. A hydroelectric station needs very little initial power to start (just enough to open the intake gates and provide excitation current to the generator field coils), and can put a large block of power on line very quickly to allow start-up of fossil-fuel or nuclear stations. Certain types of combustion turbine can be configured for black start, providing another option in places without suitable hydroelectric plants.[37] In 2017 a utility in Southern California has successfully demonstrated the use of a battery energy storage system to provide a black start, firing up a combined cycle gas turbine from an idle state.[38] Obsolescence Despite novel institutional arrangements and network designs, power delivery infrastructures is experiencing aging across the developed world. Contributing factors include: Aging equipment – older equipment has higher failure rates, leading to customer interruption rates affecting the economy and society; also, older assets and facilities lead to higher inspection maintenance costs and further repair and restoration costs. Obsolete system layout – older areas require serious additional substation sites and rights-of-way that cannot be obtained in the current area and are forced to use existing, insufficient facilities. Outdated engineering – traditional tools for power delivery planning and engineering are ineffective in addressing current problems of aged equipment, obsolete system layouts, and modern deregulated loading levels. Old cultural value – planning, engineering, operating of system using concepts and procedures that worked in vertically integrated industry exacerbate the problem under a deregulated industry.[39] Trends Demand response Demand response is a grid management technique where retail or wholesale customers are requested or incentivised either electronically or manually to reduce their load. Currently, transmission grid operators use demand response to request load reduction from major energy users such as industrial plants.[40] Technologies such as smart metering can encourage customers to use power when electricity is plentiful by allowing for variable pricing. Smart grid This section is an excerpt from Smart grid.[edit] Characteristics of a traditional centralized electrical system (left) vis-à-vis those of a smart grid (right) The smart grid is an enhancement of the 20th century electrical grid, using two-way communications and distributed so-called intelligent devices.[41] Two-way flows of electricity and information could improve the delivery network. Research is mainly focused on three systems of a smart grid – the infrastructure system, the management system, and the protection system.[42] Electronic power conditioning and control of the production and distribution of electricity are important aspects of the smart grid.[43] The smart grid represents the full suite of current and proposed responses to the challenges of electricity supply. Numerous contributions to the overall improvement of energy infrastructure efficiency are anticipated from the deployment of smart grid technology, in particular including demand-side management. The improved flexibility of the smart grid permits greater penetration of highly variable renewable energy sources such as solar power and wind power, even without the addition of energy storage. Smart grids could also monitor/control residential devices that are noncritical during periods of peak power consumption, and return their function during nonpeak hours.[44] A smart grid includes a variety of operation and energy measures: Advanced metering infrastructure (of which smart meters are a generic name for any utility side device even if it is more capable e.g. a fiber optic router) Smart distribution boards and circuit breakers integrated with home control and demand response (behind the meter from a utility perspective) oLoad control switches and smart appliances, often financed by efficiency gains on municipal programs (e.g. PACE financing) Renewable energy resources, including the capacity to charge parked (electric vehicle) batteries or larger arrays of batteries recycled from these, or other energy storage. Energy efficient resources Electric surplus distribution by power lines and auto-smart switch Sufficient utility grade fiber broadband to connect and monitor the above, with wireless as a backup. Sufficient spare if "dark" capacity to ensure failover, often leased for revenue.[45][46] Concerns with smart grid technology mostly focus on smart meters, items enabled by them, and general security issues. Roll-out of smart grid technology also implies a fundamental re-engineering of the electricity services industry, although typical usage of the term is focused on the technical infrastructure.[47] Smart grid policy is organized in Europe as Smart Grid European Technology Platform.[48] Policy in the United States is described in Title 42 of the United States Code.[49] Grid defection Resistance to distributed generation among grid operators may encourage providers to leave the grid and instead distribute power to smaller geographies.[50][51][52] The Rocky Mountain Institute[53] and other studies[54] foresee widescale grid defection. However, grid defection may be less likely in places such as Germany that have greater power demands in the winter.[55] History Early electric energy was produced near the device or service requiring that energy. In the 1880s, electricity competed with steam, hydraulics, and especially coal gas. Coal gas was first produced on customer's premises but later evolved into gasification plants that enjoyed economies of scale. In the industrialized world, cities had networks of piped gas, used for lighting. But gas lamps produced poor light, wasted heat, made rooms hot and smoky, and gave off hydrogen and carbon monoxide. They also posed a fire hazard. In the 1880s electric lighting soon became advantageous compared to gas lighting. Electric utility companies established central stations to take advantage of economies of scale and moved to centralized power generation, distribution, and system management.[56] After the war of the currents was settled in favor of AC power, with long-distance power transmission it became possible to interconnect stations to balance the loads and improve load factors. Historically, transmission and distribution lines were owned by the same company, but starting in the 1990s, many countries have liberalized the regulation of the electricity market in ways that have led to the separation of the electricity transmission business from the distribution business.[57] In the United Kingdom, Charles Merz, of the Merz & McLellan consulting partnership, built the Neptune Bank Power Station near Newcastle upon Tyne in 1901,[58] and by 1912 had developed into the largest integrated power system in Europe.[59] Merz was appointed head of a parliamentary committee and his findings led to the Williamson Report of 1918, which in turn created the Electricity (Supply) Act 1919. The bill was the first step towards an integrated electricity system. In 1925 the Weir Committee recommended the creation of a "national gridiron" and so the Electricity (Supply) Act 1926 created the Central Electricity Board (CEB).[60] The CEB standardized the nation's electricity supply and established the first synchronized AC grid, running at 132 kilovolts and 50 hertz but initially operated as regional grids. After brief overnight interconnection in 1937 they permanently and officially joined in 1938 becoming the UK National Grid. In France, electrification began in the 1900s, with 700 communes in 1919, and 36,528 in 1938. At the same time, these close networks began to interconnect: Paris in 1907 at 12 kV, the Pyrénées in 1923 at 150 kV, and finally almost all of the country interconnected by 1938 at 220 kV. In 1946, the grid was the world's most dense. That year the state nationalised the industry, by uniting the private companies as Électricité de France. The frequency was standardised at 50 Hz, and the 225 kV network replaced 110 kV and 120 kV. Since 1956, service voltage has been standardised at 220/380 V, replacing the previous 127/220 V. During the 1970s, the 400 kV network, the new European standard, was implemented. Starting on May 29, 1986, the end user service voltage will progressively change to 230/400 V +/-10%.[61][62] In the United States in the 1920s, utilities formed joint-operations to share peak load coverage and backup power. In 1934, with the passage of the Public Utility Holding Company Act (USA), electric utilities were recognized as public goods of importance and were given outlined restrictions and regulatory oversight of their operations. The Energy Policy Act of 1992 required transmission line owners to allow electric generation companies open access to their network[56][63] and led to a restructuring of how the electric industry operated in an effort to create competition in power generation. No longer were electric utilities built as vertical monopolies, where generation, transmission and distribution were handled by a single company. Now, the three stages could be split among various companies, in an effort to provide fair access to high voltage transmission.[20][21] The Energy Policy Act of 2005 allowed incentives and loan guarantees for alternative energy production and advance innovative technologies that avoided greenhouse emissions. In China, electrification began in the 1950s.[64] In August 1961, the electrification of the Baoji-Fengzhou section of the Baocheng Railway was completed and delivered for operation, becoming China's first electrified railway.[65] From 1958 to 1998, China's electrified railway reached 6,200 miles (10,000 kilometres).[66] As of the end of 2017, this number has reached 54,000 miles (87,000 kilometres).[67] In the current railway electrification system of China, State Grid Corporation of China—Archived 2021-12-21 at the Wayback Machine—is an important power supplier. In 2019, it completed the power supply project of China's important electrified railways in its operating areas, such as Jingtong Railway, Haoji Railway, Zhengzhou–Wanzhou high-speed railway, et cetera, providing power supply guarantee for 110 traction stations, and its cumulative power line construction length reached 6,586 kilometres.[68] Contents (Top) Background References National Energy Regulator of South Africa Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia National Energy Regulator of South Africa Agency overview Formed 2005; 20 years ago Jurisdiction South Africa Headquarters Kulawula House, 526 Madiba Street, Arcadia, Pretoria Agency executives Thembani Bukula, Chairperson Nomalanga Sithole, CEO Website https://www.nersa.org.za/ National Energy Regulator of South Africa (NERSA), is the regulatory authority for the electricity supply industry in South Africa.[1] Background National Energy Regulator of South Africa was established to regulate the energy industry in South Africa and to follow government standards, laws, policies and international best practices in support of sustainable development.[2][3][4] It was established by the section 3 of the National Energy Regulator Act, 2004 (Act No. 40 of 2004). NERSA's mandate is to regulate the electricity, piped-gas and petroleum pipelines industries in terms of the 2001 Gas Act, Petroleum Pipelines act of 2003 and the Electricity Regulation Act..[5][6] In November 2020, NERSA announced it was approving the procurement of 2,500 megawatts of nuclear power by the Department of Mineral Resources and Energy skom Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia Not to be confused with other similarly-named but unrelated businesses known as Escom. Eskom Company type Public utility Traded as JSE: BIESKM Industry Energy Founded 1 March 1923; 101 years ago Headquarters Sunninghill, Sandton, South Africa Key people Mteto Nyati (Chairman) Dan Marokane (Group Chief Executive) Calib Cassim (Chief Financial Officer) Services Electricity generation, transmission and distribution Revenue R 204.3 billion (FY2021)[1] US$ 13.82 billion Net income R-18.9 billion (FY2021)[1] US$ -1.28 billion Total assets R 781 billion (FY2021)[1] US$52.84 billion Number of employees 42,749 (FY2021)[1] Subsidiaries List ASN 37121 Website www.eskom.co.za Eskom Hld SOC Ltd or Eskom is a South African electricity public utility. Eskom was established in 1923 as the Electricity Supply Commission (ESCOM) (Afrikaans: Elektrisiteitsvoorsieningskommissie (EVKOM)). Eskom represents South Africa in the Southern African Power Pool. The utility is the largest producer of electricity in Africa,[2][3] and was among the top utilities in the world in terms of generation capacity and sales. It is the largest of South Africa's state owned enterprises. Eskom operates a number of notable power stations, including Matimba Power Station and Medupi Power Station in Lephalale, Kusile Power Station in Witbank, Kendal Power Station, and Koeberg Nuclear Power Station in the Western Cape Province, the only nuclear power plant in Africa. The company is divided into Generation, Transmission and Distribution divisions, and together Eskom generates approximately 95% of electricity used in South Africa, amounting to ~45% used in Africa,[4] and emits 42% of South Africa's total greenhouse gas emissions.[5][6][7][8] By releasing 1.6 million tons of sulphur dioxide into the air in 2019, Eskom is also the largest emitter of sulphur dioxide in the power industry in the world.[9] Eskom has periodically implemented rolling blackouts since January 2008, a practice ascribed to basic dereliction of duty by former president Thabo Mbeki.[10] Implementation of new generating capacity during this period was fraught with delays and cost overruns which brought the utility to the brink of bankruptcy.[11] In 2019, it was announced that Eskom was to be split up into three distinct nationally owned entities due to huge debts and poor reliability of supply.[12] At the 2021 United Nations Climate Change Conference, a deal was announced for developed countries to fund South Africa's transition from coal power to renewable energy. However, employment in the mining sector threatens this transition.[13] History The Congella Power Station completed in 1928 was one of the first power plants built and owned by Eskom. Prior to the establishment of Eskom, the provision of electricity was dominated by municipalities and private companies. The city of Kimberley was one of the first users of public electricity when it installed electric streetlights in 1882 to reduce crime at night.[14]: 5 [15] This was followed by Cape Town in 1895 with the construction of the Graaff Electric Lighting Works to power 775 street lights. Eskom was founded by the Electricity Act of 1922 which allowed the South African Electricity Control Board to appoint Hendrik Johannes van der Bijl as chairman.[16] The company changed its name by combining the two acronyms in its previous name (ESCOM and ESKOM) in 1987 to become known as Eskom. The Electricity Act stated that Eskom could only sell electricity at cost and was exempted from tax with the firm initially raising capital through the issuing of debentures, later issuing state-guaranteed loans instead. The coal-fired Congella Power Station in Durban and Salt River Power Station in Cape Town were the first power stations built by Eskom, both completed in mid-1928.[17] One of Eskom's first power plants was a coal-fired 128 MW station in Witbank, completed in 1935 to provide power to the mining industry. The plant was built and run in partnership with the privately owned Victoria Falls and Transvaal Power Company, which owned a number of other power plants across the country. Thanks to state support, Eskom was able to buy out the Victoria Falls and Transvaal Power Company in 1948 for £14.5 million (roughly equivalent to £2.55 billion in 2017). Following World War 2, South Africa experienced power shortages that led to Eskom negotiating power saving agreements with the mining industry in June 1948.[14]: 6 First expansion period: 1960-1994 Arnot Power Station completed in 1975 was one of the first of the "six-pack" coal-fired power plants built during this period that Eskom was well known for. From 1960 to 1990 Eskom increased its installed power production capacity from 4,000 MW to 40,000 MW so as to keep up with rapid economic growth in the 1960s and 70s.[14]: 4 During the same period, Eskom established a nationwide 400 kV power network. During this period the company built a number of large standardised coal-fired power plants that could produce power at very low cost due to the large economies of scale. These plants were known colloquially as "six-packs" for the 6 large generator units they were designed to accommodate.[14]: 7 In 1974 the company was instructed to start work on Koeberg nuclear power station to both provide power to Cape Town and help facilitate the South African government's nuclear program.[14]: 7 In 1981 Eskom was involved in one of its first large financial scandals when its Assistant Chief Accountant was caught embezzling R8 million from the company[14]: 7 (equivalent to roughly R164.37 million in 2018).[18] During the 1970s the company controversially sought to increase electrical tariffs to help pay for its large expansion plans. Due to its financial situation, the government appointed Dr. W.J. de Villiers to chair a commission that recommended a number of financial and organisational changes for the company to adopt. This led to the company abandoning its no-profit objective and to raise funds by taking out international loans. The number of Eskom employees was also reduced from 66,000 to 60,000 in the late-1980s.[14]: 8 Post-1994 election period: 1994-2007 Following democratic elections in 1994 and the start of the Mandela government the company changed focus to electrification of previously neglected residential homes and to provide low cost electricity for economic growth. Following the passing of the 1998 Eskom Amendment Act government's powers to influence company policy and investment decisions were greatly expanded.[14]: 8–9 Due to the South African government's attempted privatisation of Eskom in the late 1990s during the administration of President Thabo Mbeki, Eskom requests for budget to build new stations were denied. After leaving the presidency, Mbeki would later state in December 2007 that this was an error, resulting in adverse affects for the South African economy.[19] Construction work on the Medupi (pictured) and Kusile coal-fired power stations was started in the 2007-2019 period as part of Eskom's capacity expansion program following the energy crisis. Load shedding and second expansion: 2007-present See also: South African energy crisis In February 2006, Eskom announced "load shedding" in the Western Cape province, due to issues experienced by Koeberg Nuclear Power Plant[20] this continued until June 2006. In January 2008, Eskom controversially introduced load shedding nationally (rolling blackouts) based on a rotating schedule, in periods where short supply threatened the integrity of the grid. Demand-side management has focused on encouraging consumers to conserve power during peak periods in order to reduce the incidence of load shedding. Following the national power shortage in 2007, Eskom embarked on an aggressive electricity production expansion programme during the administration of President Jacob Zuma. The Zuma administration decided to focus expansion efforts on building additional large scale six-pack coal-fired power plants.[21] In 2016, Eskom stated it intended to pursue a nuclear solution to the country's energy shortage. According to projections from late 2016, the use of nuclear power would provide over 1000GW of power by 2050. In preparation, the company launched a training program for 100 technicians, engineers and artisans that would certify them as nuclear operators.[22] In January 2018, Eskom's acting chief financial officer stated that the company could not afford a new build, following a 34% drop in interim profits due to declining sales and increasing financing costs. The government stated it would proceed with the plan but more slowly.[23] In 2017, Eskom was the focus of a major corruption scandal involving the Gupta family and the administration of then President Jacob Zuma. The National Energy Regulator of South Africa denied an application by Eskom to increase electricity tariffs by a future 19.9% for the financial year 2018/19. The regulator instead granted a 5.2% increase and gave a list of reasons for the refusal to grant higher tariffs that the South African newspaper Business Day stated painted "a picture of inefficiency, inaccurate forecasting and cost overruns" at the power utility. Part of the refusal was the finding that Eskom had 6,000 more employees than needed, costing the company R3.8 billion annually.[24] In February 2019, shortly after the announcement by government that the company would be broken up, Eskom initiated another round of emergency load shedding. Eskom stated that the 2019 load shedding was initiated due to breakdowns at power stations as well as the depletion of water and diesel resources. Other reasons cited included legacy issues from state capture corruption, coal availability, and that new power plants such as Medupi and Kusile were not yet operational.[25][26] Corruption during the Zuma administration had been noted as a major factor in the cost overruns and long delays in completing Medupi and Kusile power plants that had a knock-on effect leading to the 2019 power shortages.[26] The power shortage and related troubles at Eskom was blamed as a significant contributing factor to a 3.2% decline in GDP growth in the first quarter of 2019,[27] prompting fears of a recession in 2019.[28] In December 2019, President Ramaphosa, deputy president David Mabuza and Ministers Gwede Mantashe and Pravin Gordhan met with Eskom's board and management to discuss about the energy crises.[29] The president attributed the recent blackouts partly to sabotage at the Tutuka Power Station in Mpumalanga which had caused a loss of 2000 megawatts of electricity,[30] and announced measures to bring an end to load-shedding. Mantashe and Gordhan were tasked with presenting ways to increase electricity capacity to the cabinet, which would include self-generation.[31] Amid the crisis, Jabu Mabuza resigned from his post as chairperson of Eskom's board in January 2020.[32] Between March and July 2020 the power supply was stable due to reduced demand during the COVID-19 lockdown,[33] but on 12 July a new round of level 2 load shedding began due to the breakdown of generating units.[34] During the winter of 2023, the country experienced Stage 6 blackouts, shaving a projected 2% off the country's GDP.[35] During the worst period, power cuts lasted 12 hours a day.[36] The company faces theft of materials for resale, sabotage to force repairs to be made at corruptly inflated prices, and assassination attempts which may be motivated by the attempt to replace coal with renewable sources.[37] Logos Eskom's logo has been an integral symbol of the company since its founding. For a brief period in 1986 Eskom had no logo when it was moving away from the company's original logo of stylised letters spelling "ESC" within a circle to the more contemporary version with a blue shield with a stylised lightning bolt in its centre. The 1987 logo was replaced in 2002 with its current logo that replaced the shield with a circle but otherwise kept the logo as it was. 1923 1987 2002 Restructuring efforts Eskom's sales have been declining by about 1% per annum. The less it sells, the higher the tariff it wants, and the less it sells – the utility death spiral. Rod Crompton, Adjunct professor African Energy Leadership Centre Wits Business School, University of the Witwatersrand[38] In December 1998, a white paper prepared by the Department of Minerals and Energy recommended that the government restructure Eskom into separate generation and transmission businesses. Although the report predicted that this action would improve power supply and reliability, it was never enacted.[39] In February 2019, these plans were resurrected during the State of the Nation address. President Ramaphosa announced that the government would be splitting Eskom up into three new state-owned entities focusing on generation, transmission and distribution.[12] This was done so as to better manage the serious operational and financial problems facing the company. By the time of the speech Eskom had a total debt burden of R419 billion[12] (US$30.8 billion) and was entering a death spiral whereby there was not enough revenue to make debt repayments.[38] In a February 2019 briefing, the Department of Public Enterprises stated that Eskom was "technically insolvent" and would not be able to operate past the next three months if it did not receive additional loans.[40] Finance

Minister Tito Mboweni then announced in his 2019 budget speech that government would be providing a R69 billion rand (US$5 billion) bail-out to Eskom over a three-year period so as to stabilise the company's serious financial situation.[41] Transmission Main article: National Transmission Company of South Africa As result of the restructuring, a transmission entity called the National Transmission Company of South Africa (NTCSA), a wholly-owned subsidiary of Eskom, would be given its own board, by 31 March 2020 in which the transmission legal entity would be responsible for hearing legislative amendments in accordance to government law. This new transmission entity would involve up to 6,000 people that are responsible of setting up thousands of kilometres of "wires" and transmission lines that would ensure electricity from the power stations to where power is needed.[42] As part of the Transmission Development Plan (TDP) for 2020–2029 Eskom has plans to increase its transmission infrastructure by approximately 4,800 km of extra high voltage transmission lines, and over 35,000 MVA of transformer capacity over the next 10 years. This new outline of reconstructing Eskom comes from new regulatory guidelines from the National Energy Regulator of South Africa (NERSA) to publish an annual TDP report. [citation needed] In July 2023, NERSA approved the National Transmission Company of South Africa to operate a transmission system in South Africa.[43] In September 2023, NERSA approved the remaining trading and import/export licences.[44] COSATU response In response to feared job losses resulting from the breakup the trade union COSATU organised a national strike and called for a moratorium on retrenchments in the private and public sectors.[45][46][47] This caused to the apparent abandonment of the government's company breakup and restructuring plans.[46][48] In July 2019 the outgoing Eskom CEO announced that Eskom had entered a "death spiral" and highlighted the need for the company to restructure.[48][49] Following the appointment of André de Ruyter as Eskom CEO trade unions National Union of Mineworkers and Solidarity stated that they would fight any government restructuring efforts that might result in job losses.[50] In December 2019 COSATU suggested that money be used from the Public Investment Corporation (PIC) to reduce Eskom's debt from around R450 billion to more manageable levels.[51] In return COSTATU proposed a number of conditions that included keeping workers employed.[52] The trade union Solidarity was strongly apposed to the COSATU proposal arguing that it put the pensions of public employees at risk.[53] The country's second biggest trade union, the Federation of Unions of South Africa, was also skeptical of COSATU's proposed plan.[54] Job losses Between 2020 and 2021, two thousand employees lost their jobs at the power utility. 6000 more jobs are reportedly at risk in order for the company to continue operating.[55] Installed capacity Main article: List of power stations in South Africa Subscribers Eskom – the only electricity utility in the country – has 16,789,974 subscribers in South Africa, comprising about one-third of the population. Fossil-fuelled power stations Power plant Province Type Date commissioned (planned) Capacity (MW) (planned) Status Notes Acacia Power Station Western Cape Gas turbine 1976 171 Operational [56] [permanent dead link] Ankerlig Power Station Western Cape Gas turbine 2007 1,338 Operational [57] Arnot Power Station Mpumalanga Coal-fired 1971-1975 2,352 Operational [58][59] Camden Power Station Mpumalanga Coal-fired 1967-1969; 2005-2008 1,561 Operational [59][60] Duvha Power Station Mpumalanga Coal-fired 1980-1984 3,600 Operational [59][61][62] Gourikwa Power Station Western Cape Gas turbine 2007 746 Operational [57] Grootvlei Power Station Mpumalanga Coal-fired 1969-1977; 2008-2011 1,180 Operational [59][63] Hendrina Power Station Mpumalanga Coal-fired 1970-1976 1,893 Operational [59][64] Kendal Power Station Mpumalanga Coal-fired 1988-1992 4,116 Operational [59][65][66] Komati Power Station Mpumalanga Coal-fired 1961-1966; 2009-2013 990 Operational [59][67] Kriel Power Station Mpumalanga Coal-fired 1976-1979 3,000 Operational [59][68][69] Kusile Power Station Mpumalanga Coal-fired (2017–2025) 3,200 (4,800) 4/6 units operational [70][71][72][73][74] Lethabo Power Station Free State Coal-fired 1985-1990 3,708 Operational [59][75] Majuba Power Station Mpumalanga Coal-fired 1996–2001 4,110 Operational [59][76][77][unreliable source?] Matimba Power Station Limpopo Coal-fired 1987-1991 3,990 Operational [59][78] Matla Power Station Mpumalanga Coal-fired 1979-1983 3,600 Operational [59][79] Medupi Power Station Limpopo Coal-fired 2015–2019 4,764 Operational [72][80][81][73][74] Port Rex Power Station Eastern Cape Gas turbine 1976 171 Operational [56] Tutuka Power Station Mpumalanga Coal-fired 1985-1990 3,654 Operational [59][82] Renewable and nuclear power stations Eskom Generation's pilot wind farm facility at Klipheuwel in the Western Cape, South Africa. Power plant Province Type Date commissioned Installed capacity (MW) Status Notes Colley Wobbles Power Station Eastern Cape Hydroelectric 1984 42 Operational Drakensberg Pumped Storage Scheme Free State Hydroelectric 1981 1,000 Operational [83] Gariep Dam Free State-Eastern Cape border Hydroelectric 1971 360 Operational [84] Ingula Pumped Storage Scheme KwaZulu-Natal Hydroelectric 2017 1,332 Operational [73][85] Koeberg Power Station Western Cape Nuclear 1984 1,860 Operational [86][87] Ncora Dam Eastern Cape Hydroelectric 1972 2.1 Operational [88] Palmiet Pumped Storage Scheme Western Cape Hydroelectric 1988 400 Operational [89][90] Sere Wind Farm Western Cape Wind Jan 2015 100 Operational [91][92][93][94] Vanderkloof Dam Northern Cape Hydroelectric 1977 240 Operational Future projects Eskom has a number of planned infrastructure projects to further expand electrical production. Tubatse Pumped Storage Scheme – 1500MWe Wind 500 – 550MWe Tasakoolo Wind farm 200 – 200Mwe Investment in renewables As of October 2019 Eskom Holdings SOC Ltd issued a tender to introduce 20 three-phase KW inverters and mountains structures. These structures are planned to distribute power to four power plants, and would introduce Eskom into the solar energy market. The African Investment Forum has announced that it has raised over $40.1 billion in investment into developing new infrastructure, related to renewable energies.[95] This is aimed to help distance itself from Eskom coal power plants, and to focus more on wind and solar developments. The African investment forum is backed up by corporate organizations and lenders, private donors, and the African Development Bank.[96] These new inverters would be align with South Africa's Integrated Resource Plan (IRP).[citation needed] South Africa's integrated resource plan The IRP supports a diverse energy mix with policy aimed to help aim to meet the need of South Africa's energy goals. The Integrated Resource Plan supports electrical infrastructure developments with an aim focused on renewable energy sources.[97] These new investments are directed towards more high efficiency, low emission standards with an emphasis on solar technologies in which 6,000 MW of new Solar PV capabilities and 14,400 MW of new wind power technologies.[98] With renewable energies, the IRP plans to increase its investment in hydro-electric power.[99] Investment in renewables, hydro, wind, solar With failing power plants and coal not working as a viable solution, progress towards a greener future is in sight for South Africa. In agreement to the Paris Agreement, South Africa needs to reduce its carbon emission and cut-back from being dependent on Coal. There is new US$11 Billion Green-Energy Initiative aimed at the development of solar and wind. This new initiative would allow loans to Eskom and below commercial rates on conditions that it would accelerate its closure of power plants and to start building renewable energy structures.[100] This plan takes the steps in moving away from coal, and investing in alternative methods that better suit their needs for the future.[citation needed] Other infrastructure In 2002, Eskom was issued a network operator licence. It embarked on a $100 million project installing fibre optic cables on 10 000 kilometres of its existing power lines for the purpose of real-time monitoring of the electrical network; 80% consists of all-dielectric lashed cabling and 10% All-dielectric self-supporting cabling. It currently has the sixth most ASN prefixes of all registered network operator licensees.[101] Corporate affairs Eskom executives including Phakamani Hadebe (CEO), front row second from the left, and Jan Oberholzer (CTO), front row far left, at a 2019 public forum in Cape Town on Eskom's financial situation. In 2011 eight out of ten Eskom board members were controversially sacked by the Zuma administration.[21] From 2015 to 2017 the Zuma administration appointed Ben Ngubane as chairperson of the board. Brian Molefe was appointed by Zuma as Eskom CEO from April 2015 to November 2016. Molefe[102] and Ngubane's[103] tenure was controversial for their involvement with the Gupta family and for allegedly allowing the company to become a vehicle for state capture.[104][105][106][107] Ngubane also controversially attempted to blacklist newspapers perceived as unfriendly to Eskom.[103] During parliament's state capture inquiry in 2017 former Eskom chairperson Zola Tsotsi (2012–2015) testified that Gupta family member Tony Gupta made threats against Tsotsi allegedly stating that Tsotsi will lose his job as he was not 'helping' the Guptas.[108] In December 2016, Matshela Koko, former head of generation for Eskom, was named as acting CEO.[109] He resigned in 2018 after being implicated in awarding contracts to a company linked to his stepdaughter.[110] Koko, along with his wife and stepdaughter, were arrested in October 2022.[111] In early 2018, following the establishment of the Ramaphosa government, multiple members of the Eskom board and executive team were replaced by government due to allegations of corruption and mismanagement.[112] Phakamani Hadebe was made acting CEO and director of Eskom in May 2018 as part of President Ramaphosa's replacement of the company's executive team.[113] A year into his term as CEO Hadebe resigned citing poor health and the difficult circumstances of the job.[114] His resignation sparked a debate amongst political parties over the difficult state of managing the financially strained state owned company[115] as well as the lack of political cover he was given to deal with labour unions and tackle corruption.[116] Six months after Hadebe's departure, former Nampak Chief Executive[117] André de Ruyter was appointed CEO of Eskom.[118][119] De Ruyter's appointment was criticised by the EFF[120] and factions within the ANC who instead wanted a black CEO appointed to the position.[121] De Ruyter resigned in December 2022 after repeated attacks on him by Gwede Mantashe, Minister of Mineral Resources and Energy[122][123][124] partly due to de Ruyter's advocacy for replacing coal with renewables as an energy source.[125] News24 reported that he was not given the support needed to succeed in the position.[126] Shortly after the announcement that de Ruyter would be leaving Eskom it was reported that he survived a poisoning attempt after he unknowingly drank a cup of coffee at his office that was laced with cyanide.[127] Financials 2011[128] 2012[129] 2013[129] 2014[130] 2015[130] 2016[131] 2017[131] 2018[132] 2019[133] 2020[1] 2021[1] Revenue (R billion) 91.45 114.8 128.9 138.3 147.7 164.2 177.1 177.4 179.8 199.5 204.3 Operating profit (R billion) 14.5 22.3 3.99 13.2 11.1 15.7 15.5 20.5 −1.77 4.41 6.68 Net income (R billion) 8.36 13.2 5.18 7.09 3.62 5.15 0.88 −2.33 −20.7 −20.8 −18.9 Total debt (R billion) 160.3 182.6 202.9 254.8 297.4 322.7 355.3 388.7 440.6 483.7 401.8 Employee benefit expenses (R billion) 16.7 20.2 23.6 25.6 25.9 29.2 33.1 29.4 33.3 33.2 32.9 Number of employees 41,778 43,473 46,266 46,919 46,490 47,978 47,658 48,628 46,665 44,772 42,749 Electrical output capacity (GWh) 237,430 237,414 232,228 231,129 226,300 238,599 220,166 221,936 218,939 214,968 201,400 In 2018 and 2019 Eskom's negative financial situation became serious as costs started exceeding income and the company started experiencing trouble raising money. For 72 hours between 26 March and 29 March 2019 it was reported that Eskom had run out of funds thereby threatening to negatively impact the broader South African economy. The situation was alleviated once Eskom secured a R3 billion commercial loan which was paid back on 2 April after the Reserve Bank disbursed R5 billion to Eskom through an emergency provision.[134] In July 2019 Eskom announced a loss of R20.7 billion due to the cost of servicing high levels of debt, the increased cost of primary energy and unpaid municipal debts.[135] Debt In late 2016, Standard & Poor's Global Ratings downgraded Eskom's credit rating further into subinvestment grade cutting its long-term credit rating to BB – two levels below the investment threshold.[136] By 2017 increasing levels of debt and corruption scandals affecting the company has led investment bank Goldman Sachs to declare Eskom as being the "biggest risk to South Africa's economy." The company had R413 billion in debt and planned to raise an additional R340 billion (US$26 billion) by 2022 thereby representing eight percent of South Africa's GDP. R218.2 billion of the company's debt consist of government guarantees.[137] Exacerbating the company's financial situation was a recorded R3 billion worth of irregular expenditures in 2017.[115] On 28 March 2018 Moody's Investors Service downgraded Eskom's credit rating to B2 from B1 stating that it was concerned with "the lack of any tangible financial support for the company in the February state budget".[138] On 24 November 2020, Moody's further downgraded Eskom's long-term credit rating to Caa1.[139] This places Eskom's credit within the "speculative grade" of investment, with a "very high credit risk". Due to the company's large size and important role as the region's primary energy producer President Ramaphosa stated that Eskom was "too big to fail" as the reason why government had to continue to fund it despite its serious financial situation.[140] In February 2023, with debt sitting at R423 billion, the South African government announced that, subject to approval from existing debt holders, it would be providing support worth R254 billion, including interest payments for the following three years and three capital payments of R78-billion in 2023/24, R66 billion in 2024/25 and R40-billion in 2025/26, with the intention to reduce Eskom's overall debt to R300 billion.[141] Chinese debt In July 2018 it was announced that Eskom had taken out a R33 billion loan from the Chinese government owned China Development Bank.[142] The loan conditions were controversially[143] not made public with accusations that it was an example of debt-trap diplomacy by China.[144] During the Zondo Commission of Inquiry into state corruption a senior Eskom executive stated that an additional R25 billion loan from the China-based company Huarong Energy Africa was improperly and controversially taken out by Eskom.[145] After the loan had been issued Eskom chairperson Jabu Mabuza stated to the Zondo Commission that Eskom would not be repaying the Huarong loan due to irregularities and corruption involved in the issuing of the loan.[146] Controversies Municipal debts A number of South African municipalities are in significant arrears in paying Eskom for electricity supplied to them. The large amount owed to Eskom has caused significant controversy given the state utilities financial difficulties and repeated periods of load-shedding.[147] By January 2020 South African municipalities owed Eskom a total of roughly R43 billion[148] (equivalent to US$2.88 billion). This had increased to R49.1 billion by July 2022.[149] Soweto The single largest South African municipality to owe Eskom for unpaid electricity is the City of Johannesburg Metropolitan Municipality in which Soweto owes R13 billion[150] to R16.4 billion[148] in 2019. In response, Eskom initiated a process of cutting off electricity to debtors in the city, which resulted in violent public protests.[151][152] The city has a history of non-payment dating back to the 1980s when non-payment was used as a form of non-violent protest against apartheid era policies.[153] This is thought to have cultivated a culture of non-payment.[150] Zimbabwe Power Exports 300MW of power are exported to Zimbabwe in a deal valued at US$2 million a month. At the end of November 2019 it was revealed that Zimbabwe owed $22 million in debt to Eskom (about 11 months in areas). Despite statements that Eskom continues to supply Zimbabwe during scheduled blackouts,[154] electricity is only supplied if Eskom does not need it.[155][156] Power shortage: 2007 - ongoing See also: South African energy crisis An election poster referring to the Eskom energy crisis in the run up to the 2019 general election. In the later months of 2007, South Africa started experiencing widespread rolling blackouts as supply fell behind demand, threatening to destabilise the national grid. With a reserve margin estimated at 8% or below,[157] such "load shedding" is implemented whenever generating units are taken offline for maintenance, repairs or re-fuelling (in the case of nuclear units). From February 2008 to November 2014 blackouts were temporarily halted due to reduced demand and maintenance stabilization.[158] This drop in demand was caused by many of the country's mines shutting down or slowing to help alleviate the burden. Load shedding was reintroduced in early November 2014. The Majuba power plant lost its capacity to generate power after a collapse of one of its coal storage silos on 1 November 2014. The Majuba power plant delivered approximately 10% of the country's entire capacity and the collapse halted the delivery of coal to the plant.[159] A second silo developed a major crack on 20 November causing the shut down of the plant again, this after temporary measures were instituted to deliver coal to the plant.[160] In 2016, Eskom said that unplanned outages had been reduced. In May 2016, former president Jacob Zuma said assurances had been given to him by Eskom management.[161] In June 2018, there was Stage 1 load shedding along with a strike over wages.[161] In February 2019, a new round of load shedding began due to the failure of coal burning boilers at some power stations due to poor quality coal. This resulted in long running periods of level 4 load shedding across the country in mid-March 2019, including night-time load shedding[162] and promised to report back.[161] The situation at Eskom and resulting energy crisis became a political issue during the 2019 South African general elections.[163][164][165] Sabotage In December 2019, load shedding reached a new high as Eskom introduced stage 6 load shedding for the first time.[166] Cyril Ramaphosa faced criticism as his departure for Egypt was announced shortly after the move to stage 6.[167] He returned early to address the problem, meeting on 11 December with the Eskom board. Ramaphosa then announced that there had been an element of sabotage involved, leading to the loss of 2000MW capacity. Ramaphosa faced criticism on social media, with many blaming incompetence rather than sabotage.[168] On 19 November 2021, Eskom announced that an initial forensic investigation found evidence that recent damage to a coal conveyor at Lethabo was the result of deliberate sabotage. Steel supports had been severed, causing a power supply pylon to collapse.[169][170] In a media briefing, de Ruyter commented that the matter had been referred to the Hawks for further investigation.[171] In May 2022 the Minister for Public Enterprises, Pravin Gordhan, reported to Parliament that additional incidents of cables being cut intentionally by saboteurs, rising theft at its power plants, and corruption around the supply of fuel oil, had greatly worsened the energy crisis and Eskom's ability to resolve it.[172] Corruption 2017 corruption scandal See also: Gupta family Eskom was forced to suspend its chief financial officer Anoj Singh in July 2017 when the Development Bank of South Africa threatened to recall a R15 billion loan if no action was taken against Eskom officials (including Singh) who were involved in corruption allegations involving the Gupta family.[115] In September 2017, Minister for Public Enterprises, Lynne Brown, instructed Eskom to take legal action against firms and individuals involved; ranging from Gupta family-owned consultancy firm Trillian Capital Partners Ltd. and consultancy firm McKinsey to Anoj Singh and acting chief executive Matshela Koko. A report compiled by Eskom and G9 Forensic found that the two consulting firms including Gupta owned Trillian made R1.6 billion (US$120 million) in fees with an additional R7.8 billion made from future contracts.[173] An investigation done by the amaBhungane Centre for Investigative Journalism found that the Gupta family had received contracts worth R11.7 billion from Eskom to supply coal between 2014 and 2017. With pressure for Eskom to sign the first coal supply contracts with Gupta-owned entities being applied on the state-owned firm by then President Jacob Zuma.[174] In 2019 South African Special Investigating Unit launched an investigation into corruption related to the construction of the Medupi and Kusile power stations as a cause of repeated construction delays and project cost increases;[175] this led to the investigation of 11 contractors for allegedly stealing R139 billion (US$9.13 billion) from the projects.[175][176] In 2019, two senior Eskom managers and two business people were charged with fraud and corruption related to the construction of the Kusile power station.[177] In January 2020 South African Minister for Public Enterprises, Pravin Gordhan, stated that cost overruns and corruption during the construction of Medupi and Kusile power stations was an important reason for the dramatic increase in Eskom electricity prices.[178] 2019 Deloitte consulting lawsuit In October 2019, Eskom's chairman Jabu Mabuza filed a court affidavit at the Johannesburg High Court to recover R207 million in consulting fees from the consulting firm Deloitte. The affidavit alleged that Eskom executives had improperly awarded two consulting contracts to the consulting firm Deloitte. According to Eskom, in one contract awarded to Deloitte, Deloitte proposed a fee of R88.8-million while the competing bids from other firms were for R14.6-million and R13.3-million. In the other contract, Deloitte's bid was R79.1-million, while the other bids were for R16-million and R9.1-million.[179] In March 2020, Deloitte agreed to pay back R150 million of the R207 million sought by Eskom. However, in a joint statement, it denied being part of any corruption, and that they acknowledged that there were technical irregularities in the process of awarding the contracts.[180] In April 2020, Deloitte told AmaBhungane that the managing director for Deloitte Africa's advisory division Thiru Pillay and the lead consultant on the Eskom contract Shamal Sivasanker had resigned effective 31 March 2020 for their roles in the Eskom event.[181] In November 2021, Eskom announced that it had appointed Deloitte as its next external auditor, as its contract with Grant Thornton was expiring at the end of that month.[182] power transmission is the bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation. The interconnected lines that facilitate this movement form a transmission network. This is distinct from the local wiring between high-voltage substations and customers, which is typically referred to as electric power distribution. The combined transmission and distribution network is part of electricity delivery, known as the electrical grid. Efficient long-distance transmission of electric power requires high voltages. This reduces the losses produced by strong currents. Transmission lines use either alternating current (AC) or direct current (DC). The voltage level is changed with transformers. The voltage is stepped up for transmission, then reduced for local distribution. A wide area synchronous grid, known as an interconnection in North America, directly connects generators delivering AC power with the same relative frequency to many consumers. North America has four major interconnections: Western, Eastern, Quebec and Texas. One grid connects most of continental Europe. Historically, transmission and distribution lines were often owned by the same company, but starting in the 1990s, many countries liberalized the regulation of the electricity market in ways that led to separate companies handling transmission and distribution.[2] System A diagram of an electric power system. The transmission system is in blue. Most North American transmission lines are high-voltage three-phase AC, although single phase AC is sometimes used in railway electrification systems. DC technology is used for greater efficiency over longer distances, typically hundreds of miles. High-voltage direct current (HVDC) technology is also used in submarine power cables (typically longer than 30 miles (50 km)), and in the interchange of power between grids that are not mutually synchronized. HVDC links stabilize power distribution networks where sudden new loads, or blackouts, in one part of a network might otherwise result in synchronization problems and cascading failures. Electricity is transmitted at high voltages to reduce the energy loss due to resistance that occurs over long distances. Power is usually transmitted through overhead power lines. Underground power transmission has a significantly higher installation cost and greater operational limitations, but lowers maintenance costs. Underground transmission is more common in urban areas or environmentally sensitive locations. Electrical energy must typically be generated at the same rate at which it is consumed. A sophisticated control system is required to ensure that power generation closely matches demand. If demand exceeds supply, the imbalance can cause generation plant(s) and transmission equipment to automatically disconnect or shut down to prevent damage. In the worst case, this may lead to a cascading series of shutdowns and a major regional blackout. The US Northeast faced blackouts in 1965, 1977, 2003, and major blackouts in other US regions in 1996 and 2011. Electric transmission networks are interconnected into regional, national, and even continent-wide networks to reduce the risk of such a failure by providing multiple redundant, alternative routes for power to flow should such shutdowns occur. Transmission companies determine the maximum reliable capacity of each line (ordinarily less than its physical or thermal limit) to ensure that spare capacity is available in the event of a failure in another part of the network. Overhead Main article: Overhead power line A four-circuit, two-voltage power transmission line; Bundled 2-ways A typical ACSR. The conductor consists of seven strands of steel surrounded by four layers of aluminium. This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) High-voltage overhead conductors are not covered by insulation. The conductor material is nearly always an aluminium alloy, formed of several strands and possibly reinforced with steel strands. Copper was sometimes used for overhead transmission, but aluminum is lighter, reduces yields only marginally and costs much less. Overhead conductors are supplied by several companies. Conductor material and shapes are regularly improved to increase capacity. Conductor sizes range from 12 mm2 (#6 American wire gauge) to 1,092 mm2 (2,156,000 circular mils area), with varying resistance and current-carrying capacity. For large conductors (more than a few centimetres in diameter), much of the current flow is concentrated near the surface due to the skin effect. The center of the conductor carries little current but contributes weight and cost. Thus, multiple parallel cables (called bundle conductors) are used for higher capacity. Bundle conductors are used at high voltages to reduce energy loss caused by corona discharge. Today, transmission-level voltages are usually considered to be 110 kV and above. Lower voltages, such as 66 kV and 33 kV, are usually considered subtransmission voltages, but are occasionally used on long lines with light loads. Voltages less than 33 kV are usually used for distribution. Voltages above 765 kV are considered extra high voltage and require different designs. Overhead transmission wires depend on air for insulation, requiring that lines maintain minimum clearances. Adverse weather conditions, such as high winds and low temperatures, interrupt transmission. Wind speeds as low as 23 knots (43 km/h) can permit conductors to encroach operating clearances, resulting in a flashover and loss of supply.[3] Oscillatory motion of the physical line is termed conductor gallop or flutter depending on the frequency and amplitude of oscillation. A five-hundred kilovolt (500 kV) three-phase transmission tower in Washington State, the line is bundled 3-ways Three abreast electrical pylons in Webster, Texas Underground Main article: Undergrounding Electric power can be transmitted by underground power cables. Underground cables take up no right-of-way, have lower visibility, and are less affected by weather. However, cables must be insulated. Cable and excavation costs are much higher than overhead construction. Faults in buried transmission lines take longer to locate and repair. In some metropolitan areas, cables are enclosed by metal pipe and insulated with dielectric fluid (usually an oil) that is either static or circulated via pumps. If an electric fault damages the pipe and leaks dielectric, liquid nitrogen is used to freeze portions of the pipe to enable draining and repair. This extends the repair period and increases costs. The temperature of the pipe and surroundings are monitored throughout the repair period.[4][5][6] Underground lines are limited by their thermal capacity, which permits less overload or re-rating lines. Long underground AC cables have significant capacitance, which reduces their ability to provide useful power beyond 50 miles (80 kilometres). DC cables are not limited in length by their capacitance. History Main article: History of electric power transmission New York City streets in 1890. Besides telegraph lines, multiple electric lines were required for each class of device requiring different voltages. Commercial electric power was initially transmitted at the same voltage used by lighting and mechanical loads. This restricted the distance between generating plant and loads. In 1882, DC voltage could not easily be increased for long-distance transmission. Different classes of loads (for example, lighting, fixed motors, and traction/railway systems) required different voltages, and so used different generators and circuits.[7][8] Thus, generators were sited near their loads, a practice that later became known as distributed generation using large numbers of small generators.[9] Transmission of alternating current (AC) became possible after Lucien Gaulard and John Dixon Gibbs built what they called the secondary generator, an early transformer provided with 1:1 turn ratio and open magnetic circuit, in 1881. The first long distance AC line was 34 kilometres (21 miles) long, built for the 1884 International Exhibition of Electricity in Turin, Italy. It was powered by a 2 kV, 130 Hz Siemens & Halske alternator and featured several Gaulard transformers with primary windings connected in series, which fed incandescent lamps. The system proved the feasibility of AC electric power transmission over long distances.[8] The first commercial AC distribution system entered service in 1885 in via dei Cerchi, Rome, Italy, for public lighting. It was powered by two Siemens & Halske alternators rated 30 hp (22 kW), 2 kV at 120 Hz and used 19 km of cables and 200 parallel-connected 2 kV to 20 V step-down transformers provided with a closed magnetic circuit, one for each lamp. A few months later it was followed by the first British AC system, serving Grosvenor Gallery. It also featured Siemens alternators and 2.4 kV to 100 V step-down transformers – one per user – with shunt-connected primaries.[10] Working to improve what he considered an impractical Gaulard-Gibbs design, electrical engineer William Stanley, Jr. developed the first practical series AC transformer in 1885.[11] Working with the support of George Westinghouse, in 1886 he demonstrated a transformer-based AC lighting system in Great Barrington, Massachusetts. It was powered by a steam engine-driven 500 V Siemens generator. Voltage was stepped down to 100 volts using the Stanley transformer to power incandescent lamps at 23 businesses over 4,000 feet (1,200 m).[12] This practical demonstration of a transformer and alternating current lighting system led Westinghouse to begin installing AC systems later that year.[11] In 1888 the first designs for an AC motor appeared. These were induction motors running on polyphase current, independently invented by Galileo Ferraris and Nikola Tesla. Westinghouse licensed Tesla's design. Practical three-phase motors were designed by Mikhail Dolivo-Dobrovolsky and Charles Eugene Lancelot Brown.[13] Widespread use of such motors were delayed many years by development problems and the scarcity of polyphase power systems needed to power them.[14][15] Westinghouse alternating current polyphase generators on display at the 1893 World's Fair in Chicago, part of their Tesla Poly-phase System. Such polyphase innovations revolutionized transmission. In the late 1880s and early 1890s smaller electric companies merged into larger corporations such as Ganz and AEG in Europe and General Electric and Westinghouse Electric in the US. These companies developed AC systems, but the technical difference between direct and alternating current systems required a much longer technical merger.[16] Alternating current's economies of scale with large generating plants and long-distance transmission slowly added the ability to link all the loads. These included single phase AC systems, poly-phase AC systems, low voltage incandescent lighting, high-voltage arc lighting, and existing DC motors in factories and street cars. In what became a universal system, these technological differences were temporarily bridged via the rotary converters and motor-generators that allowed the legacy systems to connect to the AC grid.[16][17] These stopgaps were slowly replaced as older systems were retired or upgraded. The first transmission of single-phase alternating current using high voltage came in Oregon in 1890 when power was delivered from a hydroelectric plant at Willamette Falls to the city of Portland 14 miles (23 km) down river.[18] The first three-phase alternating current using high voltage took place in 1891 during the international electricity exhibition in Frankfurt. A 15 kV transmission line, approximately 175 km long, connected Lauffen on the Neckar and Frankfurt.[10][19] Transmission voltages increased throughout the 20th century. By 1914, fifty-five transmission systems operating at more than 70 kV were in service. The highest voltage then used was 150 kV.[20] Interconnecting multiple generating plants over a wide area reduced costs. The most efficient plants could be used to supply varying loads during the day. Reliability was improved and capital costs were reduced, because stand-by generating capacity could be shared over many more customers and a wider area. Remote and low-cost sources of energy, such as hydroelectric power or mine-mouth coal, could be exploited to further lower costs.[7][10] The 20th century's rapid industrialization made electrical transmission lines and grids critical infrastructure. Interconnection of local generation plants and small distribution networks was spurred by World War I, when large electrical generating plants were built by governments to power munitions factories.[21] Bulk transmission A transmission substation decreases the voltage of incoming electricity, allowing it to connect from long-distance high-voltage transmission, to local lower voltage distribution. It also reroutes power to other transmission lines that serve local markets. This is the PacifiCorp Hale Substation, Orem, Utah, US. These networks use components such as power lines, cables, circuit breakers, switches and transformers. The transmission network is usually administered on a regional basis by an entity such as a regional transmission organization or transmission system operator.[22] Transmission efficiency is improved at higher voltage and lower current. The reduced current reduces heating losses. Joule's first law states that energy losses are proportional to the square of the current. Thus, reducing the current by a factor of two lowers the energy lost to conductor resistance by a factor of four for any given size of conductor. The optimum size of a conductor for a given voltage and current can be estimated by Kelvin's law for conductor size, which states that size is optimal when the annual cost of energy wasted in resistance is equal to the annual capital charges of providing the conductor. At times of lower interest rates and low commodity costs, Kelvin's law indicates that thicker wires are optimal. Otherwise, thinner conductors are indicated. Since power lines are designed for long-term use, Kelvin's law is used in conjunction with long-term estimates of the price of copper and aluminum as well as interest rates. Higher voltage is achieved in AC circuits by using a step-up transformer. High-voltage direct current (HVDC) systems require relatively costly conversion equipment that may be economically justified for particular projects such as submarine cables and longer distance high capacity point-to-point transmission. HVDC is necessary for sending energy between unsynchronized grids. A transmission grid is a network of power stations, transmission lines, and substations. Energy is usually transmitted within a grid with three-phase AC. Single-phase AC is used only for distribution to end users since it is not usable for large polyphase induction motors. In the 19th century, two-phase transmission was used but required either four wires or three wires with unequal currents. Higher order phase systems require more than three wires, but deliver little or no benefit. The synchronous grids of Europe While the price of generating capacity is high, energy demand is variable, making it often cheaper to import needed power than to generate it locally. Because loads often rise and fall together across large areas, power often comes from distant sources. Because of the economic benefits of load sharing, wide area transmission grids may span countries and even continents. Interconnections between producers and consumers enables power to flow even if some links are inoperative. The slowly varying portion of demand is known as the base load and is generally served by large facilities with constant operating costs, termed firm power. Such facilities are nuclear, coal or hydroelectric, while other energy sources such as concentrated solar thermal and geothermal power have the potential to provide firm power. Renewable energy sources, such as solar photovoltaics, wind, wave, and tidal, are, due to their intermittency, not considered to be firm. The remaining or peak power demand, is supplied by peaking power plants, which are typically smaller, faster-responding, and higher cost sources, such as combined cycle or combustion turbine plants typically fueled by natural gas. Long-distance transmission (hundreds of kilometers) is cheap and efficient, with costs of US$0.005–0.02 per kWh, compared to annual averaged large producer costs of US$0.01–0.025 per kWh, retail rates upwards of US$0.10 per kWh, and multiples of retail for instantaneous suppliers at unpredicted high demand moments.[23] New York often buys over 1000 MW of low-cost hydropower from Canada.[24] Local sources (even if more expensive and infrequently used) can protect the power supply from weather and other disasters that can disconnect distant suppliers. A high-power electrical transmission tower, 230 kV, double-circuit, also double-bundled Hydro and wind sources cannot be moved closer to big cities, and solar costs are lowest in remote areas where local power needs are nominal. Connection costs can determine whether any particular renewable alternative is economically realistic. Costs can be prohibitive for transmission lines, but high capacity, long distance super grid transmission network costs could be recovered with modest usage fees. Grid input This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) At power stations, power is produced at a relatively low voltage between about 2.3 kV and 30 kV, depending on the size of the unit. The voltage is then stepped up by the power station transformer to a higher voltage (115 kV to 765 kV AC) for transmission. In the United States, power transmission is, variously, 230 kV to 500 kV, with less than 230 kV or more than 500 kV as exceptions. The Western Interconnection has two primary interchange voltages: 500 kV AC at 60 Hz, and ±500 kV (1,000 kV net) DC from North to South (Columbia River to Southern California) and Northeast to Southwest (Utah to Southern California). The 287.5 kV (Hoover Dam to Los Angeles line, via Victorville) and 345 kV (Arizona Public Service (APS) line) are local standards, both of which were implemented before 500 kV became practical. Losses Transmitting electricity at high voltage reduces the fraction of energy lost to Joule heating, which varies by conductor type, the current, and the transmission distance. For example, a 100 miles (160 km) span at 765 kV carrying 1000 MW of power can have losses of 0.5% to 1.1%. A 345 kV line carrying the same load across the same distance has losses of 4.2%.[25] For a given amount of power, a higher voltage reduces the current and thus the resistive losses. For example, raising the voltage by a factor of 10 reduces the current by a corresponding factor of 10 and therefore the losses by a factor of 100, provided the same sized conductors are used in both cases. Even if the conductor size (cross-sectional area) is decreased ten-fold to match the lower current, the losses are still reduced ten-fold using the higher voltage. While power loss can also be reduced by increasing the wire's conductance (by increasing its cross-sectional area), larger conductors are heavier and more expensive. And since conductance is proportional to cross-sectional area, resistive power loss is only reduced proportionally with increasing cross-sectional area, providing a much smaller benefit than the squared reduction provided by multiplying the voltage. Long-distance transmission is typically done with overhead lines at voltages of 115 to 1,200 kV. At higher voltages, where more than 2,000 kV exists between conductor and ground, corona discharge losses are so large that they can offset the lower resistive losses in the line conductors. Measures to reduce corona losses include larger conductor diameter, hollow cores[26] or conductor bundles. Factors that affect resistance and thus loss include temperature, spiraling, and the skin effect. Resistance increases with temperature. Spiraling, which refers to the way stranded conductors spiral about the center, also contributes to increases in conductor resistance. The skin effect causes the effective resistance to increase at higher AC frequencies. Corona and resistive losses can be estimated using a mathematical model.[27] US transmission and distribution losses were estimated at 6.6% in 1997,[28] 6.5% in 2007[28] and 5% from 2013 to 2019.[29] In general, losses are estimated from the discrepancy between power produced (as reported by power plants) and power sold; the difference constitutes transmission and distribution losses, assuming no utility theft occurs. As of 1980, the longest cost-effective distance for DC transmission was 7,000 kilometres (4,300 miles). For AC it was 4,000 kilometres (2,500 miles), though US transmission lines are substantially shorter.[23] In any AC line, conductor inductance and capacitance can be significant. Currents that flow solely in reaction to these properties, (which together with the resistance define the impedance) constitute reactive power flow, which transmits no power to the load. These reactive currents, however, cause extra heating losses. The ratio of real power transmitted to the load to apparent power (the product of a circuit's voltage and current, without reference to phase angle) is the power factor. As reactive current increases, reactive power increases and power factor decreases. For transmission systems with low power factor, losses are higher than for systems with high power factor. Utilities add capacitor banks, reactors and other components (such as phase-shifters; static VAR compensators; and flexible AC transmission systems, FACTS) throughout the system help to compensate for the reactive power flow, reduce the losses in power transmission and stabilize system voltages. These measures are collectively called 'reactive support'. Transposition This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) Current flowing through transmission lines induces a magnetic field that surrounds the lines of each phase and affects the inductance of the surrounding conductors of other phases. The conductors' mutual inductance is partially dependent on the physical orientation of the lines with respect to each other. Three-phase lines are conventionally strung with phases separated vertically. The mutual inductance seen by a conductor of the phase in the middle of the other two phases is different from the inductance seen on the top/bottom. Unbalanced inductance among the three conductors is problematic because it may force the middle line to carry a disproportionate amount of the total power transmitted. Similarly, an unbalanced load may occur if one line is consistently closest to the ground and operates at a lower impedance. Because of this phenomenon, conductors must be periodically transposed along the line so that each phase sees equal time in each relative position to balance out the mutual inductance seen by all three phases. To accomplish this, line position is swapped at specially designed transposition towers at regular intervals along the line using various transposition schemes. Subtransmission A 115 kV subtransmission line in the Philippines, along with 20 kV distribution lines and a street light, all mounted on a wood subtransmission pole 115 kV H-frame transmission tower This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) Subtransmission runs at relatively lower voltages. It is uneconomical to connect all distribution substations to the high main transmission voltage, because that equipment is larger and more expensive. Typically, only larger substations connect with this high voltage. Voltage is stepped down before the current is sent to smaller substations. Subtransmission circuits are usually arranged in loops so that a single line failure does not stop service to many customers for more than a short time. Loops can be normally closed, where loss of one circuit should result in no interruption, or normally open where substations can switch to a backup supply. While subtransmission circuits are usually carried on overhead lines, in urban areas buried cable may be used. The lower-voltage subtransmission lines use less right-of-way and simpler structures; undergrounding is less difficult. No fixed cutoff separates subtransmission and transmission, or subtransmission and distribution. Their voltage ranges overlap. Voltages of 69 kV, 115 kV, and 138 kV are often used for subtransmission in North America. As power systems evolved, voltages formerly used for transmission were used for subtransmission, and subtransmission voltages became distribution voltages. Like transmission, subtransmission moves relatively large amounts of power, and like distribution, subtransmission covers an area instead of just point-to-point.[30] Transmission grid exit Substation transformers reduce the voltage to a lower level for distribution to customers. This distribution is accomplished with a combination of sub-transmission (33 to 138 kV) and distribution (3.3 to 25 kV). Finally, at the point of use, the energy is transformed to end-user voltage (100 to 4160 volts). Advantage of high-voltage transmission See also: Ideal transformer This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) High-voltage power transmission allows for lesser resistive losses over long distances. This efficiency delivers a larger proportion of the generated power to the loads. Electrical grid without a transformer Electrical grid with a transformer In a simplified model, the grid delivers electricity from an ideal voltage source with voltage , delivering a power) to a single point of consumption, modelled by a resistance , when the wires are long enough to have a significant resistance . If the resistances are in series with no intervening transformer, the circuit acts as a voltage divider, because the same current runs through the wire resistance and the powered device. As a consequence, the useful power (at the point of consumption) is: Should an ideal transformer convert high-voltage, low-current electricity into low-voltage, high-current electricity with a voltage ratio of (i.e., the voltage is divided by and the current is multiplied by in the secondary branch, compared to the primary branch), then the circuit is again equivalent to a voltage divider, but the wires now have apparent resistance of only . The useful power is then: For (i.e. conversion of high voltage to low voltage near the consumption point), a larger fraction of the generator's power is transmitted to the consumption point and a lesser fraction is lost to Joule heating. Modeling Main article: Performance and modelling of AC transmission This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) "Black box" model for transmission line The terminal characteristics of the transmission line are the voltage and current at the sending (S) and receiving (R) ends. The transmission line can be modeled as a black box and a 2 by 2 transmission matrix is used to model its behavior, as follows: The line is assumed to be a reciprocal, symmetrical network, meaning that the receiving and sending labels can be switched with no consequence. The transmission matrix T has the properties: The parameters A, B, C, and D differ depending on how the desired model handles the line's resistance (R), inductance (L), capacitance (C), and shunt (parallel, leak) conductance G. The four main models are the short line approximation, the medium line approximation, the long line approximation (with distributed parameters), and the lossless line. In such models, a capital letter such as R refers to the total quantity summed over the line and a lowercase letter such as c refers to the per-unit-length quantity. Lossless line The lossless line approximation is the least accurate; it is typically used on short lines where the inductance is much greater than the resistance. For this approximation, the voltage and current are identical at the sending and receiving ends. Voltage on sending and receiving ends for lossless line The characteristic impedance is pure real, which means resistive for that impedance, and it is often called surge impedance. When a lossless line is terminated by surge impedance, the voltage does not drop. Though the phase angles of voltage and current are rotated, the magnitudes of voltage and current remain constant along the line. For load > SIL, the voltage drops from sending end and the line consumes VARs. For load < SIL, the voltage increases from the sending end, and the line generates VARs. Short line The short line approximation is normally used for lines shorter than 80 km (50 mi). There, only a series impedance Z is considered, while C and G are ignored. The final result is that A = D = 1 per unit, B = Z Ohms, and C = 0. The associated transition matrix for this approximation is therefore: Medium line The medium line approximation is used for lines running between 80 and 250 km (50 and 155 mi). The series impedance and the shunt (current leak) conductance are considered, placing half of the shunt conductance at each end of the line. This circuit is often referred to as a nominal π (pi) circuit because of the shape (π) that is taken on when leak conductance is placed on both sides of the circuit diagram. The analysis of the medium line produces: Counterintuitive behaviors of medium-length transmission lines: voltage rise at no load or small current (Ferranti effect) receiving-end current can exceed sending-end current Long line The long line model is used when a higher degree of accuracy is needed or when the line under consideration is more than 250 km (160 mi) long. Series resistance and shunt conductance are considered to be distributed parameters, such that each differential length of the line has a corresponding differential series impedance and shunt admittance. The following result can be applied at any point along the transmission line, where is the propagation constant. To find the voltage and current at the end of the long line, should be replaced with (the line length) in all parameters of the transmission matrix. This model applies the Telegrapher's equations. High-voltage direct current Main article: High-voltage direct current High-voltage direct current (HVDC) is used to transmit large amounts of power over long distances or for interconnections between asynchronous grids. When electrical energy is transmitted over very long distances, the power lost in AC transmission becomes appreciable and it is less expensive to use direct current instead. For a long transmission line, these lower losses (and reduced construction cost of a DC line) can offset the cost of the required converter stations at each end. HVDC is used for long submarine cables where AC cannot be used because of cable capacitance.[31] In these cases special high-voltage cables are used. Submarine HVDC systems are often used to interconnect the electricity grids of islands, for example, between Great Britain and continental Europe, between Great Britain and Ireland, between Tasmania and the Australian mainland, between the North and South Islands of New Zealand, between New Jersey and New York City, and between New Jersey and Long Island. Submarine connections up to 600 kilometres (370 mi) in length have been deployed.[32] HVDC links can be used to control grid problems. The power transmitted by an AC line increases as the phase angle between source end voltage and destination ends increases, but too large a phase angle allows the systems at either end to fall out of step. Since the power flow in a DC link is controlled independently of the phases of the AC networks that it connects, this phase angle limit does not exist, and a DC link is always able to transfer its full rated power. A DC link therefore stabilizes the AC grid at either end, since power flow and phase angle can then be controlled independently. As an example, to adjust the flow of AC power on a hypothetical line between Seattle and Boston would require adjustment of the relative phase of the two regional electrical grids. This is an everyday occurrence in AC systems, but one that can become disrupted when AC system components fail and place unexpected loads on the grid. With an HVDC line instead, such an interconnection would: Convert AC in Seattle into HVDC; Use HVDC for the 3,000 miles (4,800 km) of cross-country transmission; and Convert the HVDC to locally synchronized AC in Boston, (and possibly in other cooperating cities along the transmission route). Such a system could be less prone to failure if parts of it were suddenly shut down. One example of a long DC transmission line is the Pacific DC Intertie located in the Western United States. Capacity This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) The amount of power that can be sent over a transmission line varies with the length of the line. The heating of short line conductors due to line losses sets a thermal limit. If too much current is drawn, conductors may sag too close to the ground, or conductors and equipment may overheat. For intermediate-length lines on the order of 100 kilometres (62 miles), the limit is set by the voltage drop in the line. For longer AC lines, system stability becomes the limiting factor. Approximately, the power flowing over an AC line is proportional to the cosine of the phase angle of the voltage and current at the ends. This angle varies depending on system loading. It is undesirable for the angle to approach 90 degrees, as the power flowing decreases while resistive losses remain. The product of line length and maximum load is approximately proportional to the square of the system voltage. Series capacitors or phase-shifting transformers are used on long lines to improve stability. HVDC lines are restricted only by thermal and voltage drop limits, since the phase angle is not material. Understanding the temperature distribution along the cable route became possible with the introduction of distributed temperature sensing (DTS) systems that measure temperatures all along the cable. Without them maximum current was typically set as a compromise between understanding of operation conditions and risk minimization. This monitoring solution uses passive optical fibers as temperature sensors, either inside a high-voltage cable or externally mounted on the cable insulation. For overhead cables the fiber is integrated into the core of a phase wire. The integrated Dynamic Cable Rating (DCR)/Real Time Thermal Rating (RTTR) solution makes it possible to run the network to its maximum. It allows the operator to predict the behavior of the transmission system to reflect major changes to its initial operating conditions. Reconductoring Some utilities have embraced reconductoring to handle the increase in electricity production. Reconductoring is the replacement-in-place of existing transmission lines with higher-capacity lines. Adding transmission lines is difficult due to cost, permit intervals, and local opposition. Reconductoring has the potential to double the amount of electricity that can travel across a transmission line.[33] A 2024 report found the United States behind countries like Belgium and the Netherlands in adoption of this technique to accommodate electrification and renewable energy. [34] In April 2022, the Biden Administration streamlined environmental reviews for such projects, and in May 2022 announced competitive grants for them funded by the 2021 Bipartisan Infrastructure Law and 2022 Inflation Reduction Act.[35] The rate of transmission expansion needs to double to support ongoing electrification and reach emission reduction targets. As of 2022, more than 10,000 power plant and energy storage projects were awaiting permission to connect to the US grid — 95% were zero-carbon resources. New power lines can take 10 years to plan, permit, and build.[33] Traditional power lines use a steel core surrounded by aluminum strands (Aluminium-conductor steel-reinforced cable). Replacing the steel with a lighter, stronger composite material such as carbon fiber (ACCC conductor) allows lines to operate at higher temperatures, with less sag, and doubled transmission capacity. Lowering line sag at high temperatures can prevent wildfires from starting when power lines touch dry vegetation.[34] Although advanced lines can cost 2-4x more than steel, total reconductoring costs are less than half of a new line, given savings in time, land acquisition, permitting, and construction.[33] A reconductoring project in southeastern Texas upgraded 240 miles of transmission lines at a cost of $900,000 per mile, versus a 3,600-mile greenfield project that averaged $1.9 million per mile.[33] Control This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) To ensure safe and predictable operation, system components are controlled with generators, switches, circuit breakers and loads. The voltage, power, frequency, load factor, and reliability capabilities of the transmission system are designed to provide cost effective performance. Load balancing The transmission system provides for base load and peak load capability, with margins for safety and fault tolerance. Peak load times vary by region largely due to the industry mix. In hot and cold climates home air conditioning and heating loads affect the overall load. They are typically highest in the late afternoon in the hottest part of the year and in mid-mornings and mid-evenings in the coldest part of the year. Power requirements vary by season and time of day. Distribution system designs always take the base load and the peak load into consideration. The transmission system usually does not have a large buffering capability to match loads with generation. Thus generation has to be kept matched to the load, to prevent overloading generation equipment. Multiple sources and loads can be connected to the transmission system and they must be controlled to provide orderly transfer of power. In centralized power generation, only local control of generation is necessary. This involves synchronization of the generation units. In distributed power generation the generators are geographically distributed and the process to bring them online and offline must be carefully controlled. The load control signals can either be sent on separate lines or on the power lines themselves. Voltage and frequency can be used as signaling mechanisms to balance the loads. In voltage signaling, voltage is varied to increase generation. The power added by any system increases as the line voltage decreases. This arrangement is stable in principle. Voltage-based regulation is complex to use in mesh networks, since the individual components and setpoints would need to be reconfigured every time a new generator is added to the mesh. In frequency signaling, the generating units match the frequency of the power transmission system. In droop speed control, if the frequency decreases, the power is increased. (The drop in line frequency is an indication that the increased load is causing the generators to slow down.) Wind turbines, vehicle-to-grid, virtual power plants, and other locally distributed storage and generation systems can interact with the grid to improve system operation. Internationally[where?], a slow move from a centralized to decentralized power systems have taken place. The main draw of locally distributed generation systems is that they reduce transmission losses by leading to consumption of electricity closer to where it was produced.[36] Failure protection Under excess load conditions, the system can be designed to fail incrementally rather than all at once. Brownouts occur when power supplied drops below the demand. Blackouts occur when the grid fails completely. Rolling blackouts (also called load shedding) are intentionally engineered electrical power outages, used to distribute insufficient power to various loads in turn. Communications This section does not cite any sources. Please help

improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) Grid operators require reliable communications to manage the grid and associated generation and distribution facilities. Fault-sensing protective relays at each end of the line must communicate to monitor the flow of power so that faulted conductors or equipment can be quickly de-energized and the balance of the system restored. Protection of the transmission line from short circuits and other faults is usually so critical that common carrier telecommunications are insufficiently reliable, while in some remote areas no common carrier is available. Communication systems associated with a transmission project may use: Microwaves Power-line communication Optical fibers Rarely, and for short distances, pilot-wires are strung along the transmission line path. Leased circuits from common carriers are not preferred since availability is not under control of the operator. Transmission lines can be used to carry data: this is called power-line carrier, or power-line communication (PLC). PLC signals can be easily received with a radio in the long wave range. High-voltage pylons carrying additional optical fibre cable in Kenya Optical fibers can be included in the stranded conductors of a transmission line, in the overhead shield wires. These cables are known as optical ground wire (OPGW). Sometimes a standalone cable is used, all-dielectric self-supporting (ADSS) cable, attached to the transmission line cross arms. Some jurisdictions, such as Minnesota, prohibit energy transmission companies from selling surplus communication bandwidth or acting as a telecommunications common carrier. Where the regulatory structure permits, the utility can sell capacity in extra dark fibers to a common carrier. Market structure Main article: Electricity market Electricity transmission is generally considered to be a natural monopoly, but one that is not inherently linked to generation.[37][38][39] Many countries regulate transmission separately from generation. Spain was the first country to establish a regional transmission organization. In that country, transmission operations and electricity markets are separate. The transmission system operator is Red Eléctrica de España (REE) and the wholesale electricity market operator is Operador del Mercado Ibérico de Energía – Polo Español, S.A. (OMEL) OMEL Holding | Omel Holding. Spain's transmission system is interconnected with those of France, Portugal, and Morocco. The establishment of RTOs in the United States was spurred by the FERC's Order 888, Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities, issued in 1996.[40] In the United States and parts of Canada, electric transmission companies operate independently of generation companies, but in the Southern United States vertical integration is intact. In regions of separation, transmission owners and generation owners continue to interact with each other as market participants with voting rights within their RTO. RTOs in the United States are regulated by the Federal Energy Regulatory Commission. Merchant transmission projects in the United States include the Cross Sound Cable from Shoreham, New York to New Haven, Connecticut, Neptune RTS Transmission Line from Sayreville, New Jersey, to New Bridge, New York, and Path 15 in California. Additional projects are in development or have been proposed throughout the United States, including the Lake Erie Connector, an underwater transmission line proposed by ITC Holdings Corp., connecting Ontario to load serving entities in the PJM Interconnection region.[41] Australia has one unregulated or market interconnector – Basslink – between Tasmania and Victoria. Two DC links originally implemented as market interconnectors, Directlink and Murraylink, were converted to regulated interconnectors.[42] A major barrier to wider adoption of merchant transmission is the difficulty in identifying who benefits from the facility so that the beneficiaries pay the toll. Also, it is difficult for a merchant transmission line to compete when the alternative transmission lines are subsidized by utilities with a monopolized and regulated rate base.[43] In the United States, the FERC's Order 1000, issued in 2010, attempted to reduce barriers to third party investment and creation of merchant transmission lines where a public policy need is found.[44] Transmission costs The cost of high voltage transmission is comparatively low, compared to all other costs constituting consumer electricity bills. In the UK, transmission costs are about 0.2 p per kWh compared to a delivered domestic price of around 10 p per kWh.[45] The level of capital expenditure in the electric power T&D equipment market was estimated to be $128.9 bn in 2011.[46] Health concerns Main article: Electromagnetic radiation and health Mainstream scientific evidence suggests that low-power, low-frequency, electromagnetic radiation associated with household currents and high transmission power lines does not constitute a short- or long-term health hazard. Some studies failed to find any link between living near power lines and developing any sickness or diseases, such as cancer. A 1997 study reported no increased risk of cancer or illness from living near a transmission line.[47] Other studies, however, reported statistical correlations between various diseases and living or working near power lines. No adverse health effects have been substantiated for people not living close to power lines.[48] The New York State Public Service Commission conducted a study[49] to evaluate potential health effects of electric fields. The study measured the electric field strength at the edge of an existing right-of-way on a 765 kV transmission line. The field strength was 1.6 kV/m, and became the interim maximum strength standard for new transmission lines in New York State. The opinion also limited the voltage of new transmission lines built in New York to 345 kV. On September 11, 1990, after a similar study of magnetic field strengths, the NYSPSC issued their Interim Policy Statement on Magnetic Fields. This policy established a magnetic field standard of 200 mG at the edge of the right-of-way using the winter-normal conductor rating. As a comparison with everyday items, a hair dryer or electric blanket produces a 100 mG – 500 mG magnetic field.[50][51] Applications for a new transmission line typically include an analysis of electric and magnetic field levels at the edge of rights-of-way. Public utility commissions typically do not comment on health impacts. Biological effects have been established for acute high level exposure to magnetic fields above 100 μT (1 G) (1,000 mG). In a residential setting, one study reported "limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals", in particular, childhood leukemia, associated with average exposure to residential power-frequency magnetic field above 0.3 μT (3 mG) to 0.4 μT (4 mG). These levels exceed average residential power-frequency magnetic fields in homes, which are about 0.07 μT (0.7 mG) in Europe and 0.11 μT (1.1 mG) in North America.[52][53] The Earth's natural geomagnetic field strength varies over the surface of the planet between 0.035 mT and 0.07 mT (35 μT – 70 μT or 350 mG – 700 mG) while the international standard for continuous exposure is set at 40 mT (400,000 mG or 400 G) for the general public.[52] Tree growth regulators and herbicides may be used in transmission line right of ways,[54] which may have health effects. Specialized transmission Grids for railways Main article: Traction power network In some countries where electric locomotives or electric multiple units run on low frequency AC power, separate single phase traction power networks are operated by the railways. Prime examples are countries such as Austria, Germany and Switzerland that utilize AC technology based on 16 2/3 Hz. Norway and Sweden also use this frequency but use conversion from the 50 Hz public supply; Sweden has a 16 2/3 Hz traction grid but only for part of the system. Superconducting cables High-temperature superconductors (HTS) promise to revolutionize power distribution by providing lossless transmission. The development of superconductors with transition temperatures higher than the boiling point of liquid nitrogen has made the concept of superconducting power lines commercially feasible, at least for high-load applications.[55] It has been estimated that waste would be halved using this method, since the necessary refrigeration equipment would consume about half the power saved by the elimination of resistive losses. Companies such as Consolidated Edison and American Superconductor began commercial production of such systems in 2007.[56] Superconducting cables are particularly suited to high load density areas such as the business district of large cities, where purchase of an easement for cables is costly.[57] HTS transmission lines[58] Location Length (km) Voltage (kV) Capacity (GW) Date Carrollton, Georgia 2000 Albany, New York[59] 0.35 34.5 0.048 2006 Holbrook, Long Island[60] 0.6 138 0.574 2008 Tres Amigas 5 Proposed 2013 Manhattan: Project Hydra Proposed 2014 Essen, Germany[61][62] 1 10 0.04 2014 Single-wire earth return Main article: Single-wire earth return This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) Single-wire earth return (SWER) or single-wire ground return is a single-wire transmission line for supplying single-phase electrical power to remote areas at low cost. It is principally used for rural electrification, but also finds use for larger isolated loads such as water pumps. Single-wire earth return is also used for HVDC over submarine power cables. Wireless power transmission Main article: Wireless power transfer This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) Both Nikola Tesla and Hidetsugu Yagi attempted to devise systems for large scale wireless power transmission in the late 1800s and early 1900s, without commercial success. In November 2009, LaserMotive won the NASA 2009 Power Beaming Challenge by powering a cable climber 1 km vertically using a ground-based laser transmitter. The system produced up to 1 kW of power at the receiver end. In August 2010, NASA contracted with private companies to pursue the design of laser power beaming systems to power low earth orbit satellites and to launch rockets using laser power beams. Wireless power transmission has been studied for transmission of power from solar power satellites to the earth. A high power array of microwave or laser transmitters would beam power to a rectenna. Major engineering and economic challenges face any solar power satellite project. Security The examples and perspective in this article may not represent a worldwide view of the subject. You may improve this article, discuss the issue on the talk page, or create a new article, as appropriate. (March 2013) (Learn how and when to remove this message) The federal government of the United States stated that the American power grid was susceptible to cyber-warfare.[63][64] The United States Department of Homeland Security works with industry to identify vulnerabilities and to help industry enhance the security of control system networks.[65] In June 2019, Russia conceded that it was "possible" its electrical grid is under cyber-attack by the United States.[66] The New York Times reported that American hackers from the United States Cyber Command planted malware potentially capable of disrupting the Russian electrical grid.[67] Records Highest capacity system: 12 GW Zhundong–Wannan (准东-皖南)±1100 kV HVDC.[68][69] Highest transmission voltage (AC): oplanned: 1.20 MV (Ultra-High Voltage) on Wardha-Aurangabad line (India), planned to initially operate at 400 kV.[70] oworldwide: 1.15 MV (Ultra-High Voltage) on Ekibastuz-Kokshetau line (Kazakhstan) Largest double-circuit transmission, Kita-Iwaki Powerline (Japan). Highest towers: Yangtze River Crossing (China) (height: 345 m or 1,132 ft) Longest power line: Inga-Shaba (Democratic Republic of Congo) (length: 1,700 kilometres or 1,056 miles) Longest span of power line: 5,376 m (17,638 ft) at Ameralik Span (Greenland, Denmark) Longest submarine cables: oNorth Sea Link, (Norway/United Kingdom) – (length of submarine cable: 720 kilometres or 447 miles) oNorNed, North Sea (Norway/Netherlands) – (length of submarine cable: 580 kilometres or 360 miles) oBasslink, Bass Strait, (Australia) – (length of submarine cable: 290 kilometres or 180 miles, total length: 370.1 kilometres or 230 miles) oBaltic Cable, Baltic Sea (Germany/Sweden) – (length of submarine cable: 238 kilometres or 148 miles, HVDC length: 250 kilometres or 155 miles, total length: 262 kilometres or 163 miles) Longest underground cables: oMurraylink, Riverland/Sunraysia (Australia) – (length of underground cable: 170 kilometres or 106 miles) See also Energy portal Dynamic demand (electric power) Demand response List of energy storage power plants Traction power network Backfeeding Conductor marking lights Double-circuit transmission line Electromagnetic Transients Program (EMTP) Flexible AC transmission system (FACTS) Geomagnetically induced current, (GIC) Graphene-clad wire Grid-tied electrical system List of high-voltage underground and submarine cables Load profile National Grid (disambiguation) Power-line communications (PLC) Power system simulation Radio frequency power transmission Wheeling (electric power transmission) References encyclopedia An electrical grid may have many types of generators and loads; generators must be controlled to maintain stable operation of the system. In an electric power system, automatic generation control (AGC) is a system for adjusting the power output of multiple generators at different power plants, in response to changes in the load. Since a power grid requires that generation and load closely balance moment by moment, frequent adjustments to the output of generators are necessary. The balance can be judged by measuring the system frequency; if it is increasing, more power is being generated than used, which causes all the machines in the system to accelerate. If the system frequency is decreasing, more load is on the system than the instantaneous generation can provide, which causes all generators to slow down. History Before the use of automatic generation control, one generating unit in a system would be designated as the regulating unit and would be manually adjusted to control the balance between generation and load to maintain system frequency at the desired value. The remaining units would be controlled with speed droop to share the load in proportion to their ratings. With automatic systems, many units in a system can participate in regulation, reducing wear on a single unit's controls and improving overall system efficiency, stability, and economy. Where the grid has tie interconnections to adjacent control areas, automatic generation control helps maintain the power interchanges over the tie lines at the scheduled levels. With computer-based control systems and multiple inputs, an automatic generation control system can take into account such matters as the most economical units to adjust, the coordination of thermal, hydroelectric, and other generation types, and even constraints related to the stability of the system and capacity of interconnections to other power grids.[1] Types Turbine-governor control Turbine generators in a power system have stored kinetic energy due to their large rotating masses. All the kinetic energy stored in a power system in such rotating masses is a part of the grid inertia. When system load increases, grid inertia is initially used to supply the load. This, however, leads to a decrease in the stored kinetic energy of the turbine generators. Since the mechanical power of these turbines correlates with the delivered electrical power, the turbine generators have a decrease in angular velocity, which is directly proportional to a decrease in frequency in synchronous generators. Steady state frequency-power relation for a turbine governor The purpose of the turbine-governor control (TGC) is to maintain the desired system frequency by adjusting the mechanical power output of the turbine.[2] These controllers have become automated and at steady state, the frequency-power relation for turbine-governor control is, where, is the change in turbine mechanical power output is the change in a reference power setting is the regulation constant which quantifies the sensitivity of the generator to a change in frequency is the change in frequency. For steam turbines, steam turbine governing adjusts the mechanical output of the turbine by increasing or decreasing the amount of steam entering the turbine via a throttle valve. Load-frequency control Load-frequency control (LFC) is employed to allow an area to first meet its own load demands, then to assist in returning the steady-state frequency of the system, Δf, to zero.[3] Load-frequency control operates with a response time of a few seconds to keep system frequency stable. Economic dispatch The goal of economic dispatch is to minimize total operating costs in an area by determining how the real power output of each generating unit will meet a given load.[4] Generating units have different costs to produce a unit of electrical energy, and incur different costs for the losses in transmitting energy to the load. An economic dispatch algorithm will run every few minutes to select the combination of generating unit power setpoints that minimizes overall cost, subject to the constraints of transmission limitation or security of the system against failures.[5] Further constraints may be imposed by the water supply of hydroelectric generation, or by the availability of sun and wind power. "Grid storage" redirects here. For data storage with grid computing, see Grid-oriented storage. Energy from fossil or nuclear power plants and renewable sources is stored for use by customers. Diagram showing flow of energy between energy storage facilities and power grids, as a function of time over a 24 hour period Grid energy storage, also known as large-scale energy storage, are technologies connected to the electrical power grid that store energy for later use. These systems help balance supply and demand by storing excess electricity from variable renewables such as solar and inflexible sources like nuclear power, releasing it when needed. They further provide essential grid services, such as helping to restart the grid after a power outage. As of 2023, the largest form of grid storage is pumped-storage hydroelectricity, with utility-scale batteries and behind-the-meter batteries coming second and third.[1] Lithium-ion batteries are highly suited for shorter duration storage up to 8 hours. Flow batteries and compressed air energy storage may provide storage for medium duration. Two forms of storage are suited for long-duration storage: green hydrogen, produced via electrolysis and thermal energy storage.[2] Energy storage is one option to making grids more flexible. An other solution is the use of more dispatchable power plants that can change their output rapidly, for instance peaking power plants to fill in supply gaps. Demand response can shift load to other times and interconnections between regions can balance out fluctuations in renewables production.[3] The price of storage technologies typically goes down with experience. For instance, lithium-ion batteries have been getting some 20% cheaper for each doubling of worldwide capacity.[4] Systems with under 40% variable renewables need only short-term storage. At 80%, medium-duration storage becomes essential and beyond 90%, long-duration storage does too. The economics of long-duration storage is challenging, and alternative flexibility options like demand response may be more economic. Roles in the power grid Any electrical power grid must match electricity production to consumption, both of which vary significantly over time. Energy derived from solar and wind sources varies with the weather on time scales ranging from less than a second to weeks or longer. Nuclear power is less flexible than fossil fuels, meaning it cannot easily match the variations in demand. Thus, low-carbon electricity without storage presents special challenges to electric utilities.[5] Electricity storage is one of the three key ways to replace flexibility from fossil fuels in the grid. Other options are demand-side response, in which consumers change when they use electricity or how much they use. For instance, households may have cheaper night tariffs to encourage them to use electricity at night. Industry and commercial consumers can also change their demand to meet supply. Improved network interconnection smooths the variations of renewables production and demand. When there is little wind in one location, another might have a surplus of production. Expansion of transmission lines usually takes a long time.[6] Potential roles of energy storage in the grid[7][8] Consumption Network Generation Short-term flexibility Increased use rooftop solar, cost reductions from time-based rates Congestion relief Renewables integration (smoothing, arbitrage) Essential grid services Backup power during outages Frequency regulation Black start System reliability and planning Creation of mini-grids Savings in transmission and distribution network Meeting peak demand Energy storage has a large set of roles in the electricity grid and can therefore provide many different services. For instance, it can arbitrage by keeping it until the electricity price rises, it can help make the grid more stable, and help reduce investment into transmission infrastructure.[9] The type of service provided by storage depends on who manages the technology, whether the technology is based alongside generation of electricity, within the network, or at the side of consumption.[8] Providing short-term flexibility is a key role for energy storage. On the generation side, it can help with the integration of variable renewable energy, storing it when there is an oversupply of wind and solar and electricity prices are low. More generally, it can exploit the changes in prices of electricity over time in the wholesale market, charging when electricity is cheap and selling when it is expensive. It can further help with grid congestion (where there is insufficient capacity on transmission lines). Consumers can use storage to use more of their self-produced electricity (for instance from rooftop solar power).[8][7] Storage can also be used to provide essential grid services. On the generation side, storage can smooth out the variations in production, for instance for solar and wind. It can assist in a black start after a power outage. On the network side, these include frequency regulation (continuously) and frequency response (after unexpected changes in supply or demand). On the consumption side, storage can help to improve the quality of the delivered electricity in less stable grids.[8][10] Investment in storage may make some investments in the transmission and distribution network unnecessary, or may allow them to be scaled down. Additionally, storage can ensure there is sufficient capacity to meet peak demand within the electricity grid. Finally, in off-grid home systems or mini-grids, electricity storage can help provide energy access in areas that were previously not connected to the electricity grid.[8] Forms Energy from sunlight or other renewable energy is converted to potential energy for storage in devices such as electric batteries. The stored potential energy is later converted to electricity that is added to the power grid, even when the original energy source is not available. In daytime, different renewable sources provide different amounts of power to the grid. At night, energy is provided by batteries that were charged during the day when renewable energy exceeded customer demand. Electricity can be stored directly for a short time in capacitors, somewhat longer electrochemically in batteries, and much longer chemically (e.g. hydrogen), mechanically (e.g. pumped hydropower) or as heat.[11] The first pumped hydroelectricity was constructed at the end of the 19th century around the Alps in Italy, Austria, and Switzerland. The technique rapidly expanded during the 1960s to 1980s nuclear boom, due to nuclear power's inability to quickly adapt to changes in electricity demand. In the 21st century, interest in storage surged due to the rise of sustainable energy sources, which are often weather-dependent.[12] Commercial batteries have been available for over a century,[13] their widespread use in the power grid is more recent, with only 1 GW available in 2013.[14] Batteries Main article: Battery energy storage system A 900 watt direct current light plant using 16 separate lead acid battery cells (32 volts) from 1917.[15] Lithium-ion batteries Lithium-ion batteries are the most commonly used batteries for grid applications, as of 2024, following the application of batteries in electric vehicles (EVs). In comparison with EVs, grid batteries require less energy density, meaning that more emphasis can be put on costs, the ability to charge and discharge often and lifespan. This has led to a shift towards lithium iron phosphate batteries (LFP batteries), which are cheaper and last longer than traditional lithium-ion batteries.[16] Costs of batteries are declining rapidly; from 2010 to 2023 costs fell by 90%.[17] As of 2024, utility-scale systems account for two thirds of added capacity, and home applications (behind-the-meter) for one third.[18] Lithium-ion batteries are highly suited to short-duration storage (50%), the temperature ratio between the two must reach a factor of 5.[61] Thermal energy storage is also used in combination with concentrated solar power (CSP). In CSP, solar energy is first converted into heat, and then either directly converted into electricity or first stored. The energy is released when there is little or no sunshine.[62] This means that CSP can be used as a dispatchable (flexible) form of generation. The energy in a CSP system can for instance be stored in molten salts or in a solid medium such as sand.[63] Finally, heating and cooling systems in buildings can be controlled to store thermal energy in either the building's mass or dedicated thermal storage tanks. This thermal storage can provide load-shifting or even more complex ancillary services by increasing power consumption (charging the storage) during off-peak times and lowering power consumption (discharging the storage) during higher-priced peak times.[64] Economics Costs Experience curve of lithium-ion batteries: the price of batteries dropped by 97% in three decades.[65][66] The levelized cost of storing electricity (LCOS) is a measure of the lifetime costs of storing electricity per MWh of electricity discharged. It includes investment costs, but also operational costs and charging costs.[67] It depends highly on storage type and purpose; as subsecond-scale frequency regulation, minute/hour-scale peaker plants, or day/week-scale season storage.[68][69][70] For power applications (for instance around ancillary services or black starts), a similar metric is the annuitized capacity cost (ACC), which measures the lifetime costs per kW. ACC is lowest when there are few cycles (<300) and when the discharge is less than one hour. This is because the technology is reimbursed only when it provides spare capacity, not when it is discharged.[71] The cost of storage is coming down following technology-dependent experience curves, the price drop for each doubling in cumulative capacity (or experience). Lithium-ion battery prices fast: the price utilities pay for them falls 19% with each doubling of capacity. Hydrogen production via electrolysis has a similar learning rate, but it is much more uncertain. Vanadium-flow batteries typically get 14% cheaper for each doubling of capacity. Pumped hydropower has not seen prices fall much with increased experience.[4] Market and system value There are four categories of services which provide economic value for storage: those related to power quality (such as frequency regulation), reliability (ensuring peak demand can be met), better use of assets in the system (e.g. avoiding transmission investments) and arbitrage (exploiting price differences over time). Before 2020, most value for storage was in providing power quality services. Arbitrage is the service with the largest economic potential for storage applications.[72] Storage requirements based on the share of variable renewable energy (VRE). For energy storage, this is the energy stored at a given time, not the total over the year[73] VRE share Power (% of peak demand) Energy storage (% of annual demand) 50% Less than 20% 0.02% 80% 20–50% 0.03–0.1% 90% 25–75% 0.05–0.2% In systems with under 40% of variable renewables, only short-term storage (of less than 4 hours) is needed for integration. When the share of variable renewables climbs to 80%, medium-duration storage (between 4 and 16 hours, for instance compressed air) is needed. Above 90%, large-scale long-duration storage is required.[74] The economics of long-duration storage is challenging even then, as the costs are high. Alternative flexibility options, such as demand response, network expansions or flexible generation (geothermal or fossil gas with carbon capture and storage) may be lower-cost.[75] Like with renewables, storage will "cannibalise" its own income, but even more strongly. That is, with more storage on the market, there is less of an opportunity to do arbitrage or deliver other services to the grid.[76] How markets are designed impacts revenue potential too. The income from arbitrage is quite variable between years, whereas markets that have capacity payments likely show less volatility.[77] Electricity storage is not 100% efficient, so more electricity needs to be bought than can be sold. This implies that if there is only a small variation in price, it may not be economical to charge and discharge. For instance, if the storage application is 75% efficient, the price at which the electricity is sold needs to be at least 1.33 higher than the price for which it was bought.[78] Typically, electricity prices vary most between day and night, which means that storage up to 8 hours has relatively high potential for profit. Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia Diagram comparing losses from conventional generation vs. cogeneration Part of a series on Sustainable energy Energy conservation Renewable energy Sustainable transport Category Renewable energy portal v t e Cogeneration or combined heat and power (CHP) is the use of a heat engine[1] or power station to generate electricity and useful heat at the same time. Cogeneration is a more efficient use of fuel or heat, because otherwise-wasted heat from electricity generation is put to some productive use. Combined heat and power (CHP) plants recover otherwise wasted thermal energy for heating. This is also called combined heat and power district heating. Small CHP plants are an example of decentralized energy.[2] By-product heat at moderate temperatures (100–180 °C (212–356 °F) can also be used in absorption refrigerators for cooling. The supply of high-temperature heat first drives a gas or steam turbine-powered generator. The resulting low-temperature waste heat is then used for water or space heating. At smaller scales (typically below 1 MW), a gas engine or diesel engine may be used. Cogeneration is also common with geothermal power plants as they often produce relatively low grade heat. Binary cycles may be necessary to reach acceptable thermal efficiency for electricity generation at all. Cogeneration is less commonly employed in nuclear power plants as NIMBY and safety considerations have often kept them further from population centers than comparable chemical power plants and district heating is less efficient in lower population density areas due to transmission losses. Cogeneration was practiced in some of the earliest installations of electrical generation. Before central stations distributed power, industries generating their own power used exhaust steam for process heating. Large office and apartment buildings, hotels, and stores commonly generated their own power and used waste steam for building heat. Due to the high cost of early purchased power, these CHP operations continued for many years after utility electricity became available.[3] Overview Masnedø CHP power station in Denmark. This station burns straw as fuel. The adjacent greenhouses are heated by district heating from the plant. Many process industries, such as chemical plants, oil refineries and pulp and paper mills, require large amounts of process heat for such operations as chemical reactors, distillation columns, steam driers and other uses. This heat, which is usually used in the form of steam, can be generated at the typically low pressures used in heating, or can be generated at much higher pressure and passed through a turbine first to generate electricity. In the turbine the steam pressure and temperature is lowered as the internal energy of the steam is converted to work. The lower-pressure steam leaving the turbine can then be used for process heat. Steam turbines at thermal power stations are normally designed to be fed high-pressure steam, which exits the turbine at a condenser operating a few degrees above ambient temperature and at a few millimeters of mercury absolute pressure. (This is called a condensing turbine.) For all practical purposes this steam has negligible useful energy before it is condensed. Steam turbines for cogeneration are designed for extraction of some steam at lower pressures after it has passed through a number of turbine stages, with the un-extracted steam going on through the turbine to a condenser. In this case, the extracted steam causes a mechanical power loss in the downstream stages of the turbine. Or they are designed, with or without extraction, for final exhaust at back pressure (non-condensing).[4][5] The extracted or exhaust steam is used for process heating. Steam at ordinary process heating conditions still has a considerable amount of enthalpy that could be used for power generation, so cogeneration has an opportunity cost. A typical power generation turbine in a paper mill may have extraction pressures of 160 and 60 psi (1.10 and 0.41 MPa). A typical back pressure may be 60 psi (0.41 MPa). In practice these pressures are custom designed for each facility. Conversely, simply generating process steam for industrial purposes instead of high enough pressure to generate power at the top end also has an opportunity cost (See: Steam supply and exhaust conditions). The capital and operating cost of high-pressure boilers, turbines, and generators is substantial. This equipment is normally operated continuously, which usually limits self-generated power to large-scale operations. A cogeneration plant in Metz, France. The 45 MW boiler uses waste wood biomass as an energy source, providing electricity and heat for 30,000 dwellings. A combined cycle (in which several thermodynamic cycles produce electricity), may also be used to extract heat using a heating system as condenser of the power plant's bottoming cycle. For example, the RU-25 MHD generator in Moscow heated a boiler for a conventional steam powerplant, whose condensate was then used for space heat. A more modern system might use a gas turbine powered by natural gas, whose exhaust powers a steam plant, whose condensate provides heat. Cogeneration plants based on a combined cycle power unit can have thermal efficiencies above 80%. The viability of CHP (sometimes termed utilisation factor), especially in smaller CHP installations, depends on a good baseload of operation, both in terms of an on-site (or near site) electrical demand and heat demand. In practice, an exact match between the heat and electricity needs rarely exists. A CHP plant can either meet the need for heat (heat driven operation) or be run as a power plant with some use of its waste heat, the latter being less advantageous in terms of its utilisation factor and thus its overall efficiency. The viability can be greatly increased where opportunities for trigeneration exist. In such cases, the heat from the CHP plant is also used as a primary energy source to deliver cooling by means of an absorption chiller. CHP is most efficient when heat can be used on-site or very close to it. Overall efficiency is reduced when the heat must be transported over longer distances. This requires heavily insulated pipes, which are expensive and inefficient; whereas electricity can be transmitted along a comparatively simple wire, and over much longer distances for the same energy loss. A car engine becomes a CHP plant in winter when the reject heat is useful for warming the interior of the vehicle. The example illustrates the point that deployment of CHP depends on heat uses in the vicinity of the heat engine. Thermally enhanced oil recovery (TEOR) plants often produce a substantial amount of excess electricity. After generating electricity, these plants pump leftover steam into heavy oil wells so that the oil will flow more easily, increasing production. Cogeneration plants are commonly found in district heating systems of cities, central heating systems of larger buildings (e.g. hospitals, hotels, prisons) and are commonly used in the industry in thermal production processes for process water, cooling, steam production or CO_2 fertilization. Rostock Power Station, a bituminous coal-fired combined heat and power plant in Germany Trigeneration or combined cooling, heat and power (CCHP) refers to the simultaneous generation of electricity and useful heating and cooling from the combustion of a fuel or a solar heat collector. The terms cogeneration and trigeneration can also be applied to the power systems simultaneously generating electricity, heat, and industrial chemicals (e.g., syngas). Trigeneration differs from cogeneration in that the waste heat is used for both heating and cooling, typically in an absorption refrigerator. Combined cooling, heat, and power systems can attain higher overall efficiencies than cogeneration or traditional power plants. In the United States, the application of trigeneration in buildings is called building cooling, heating, and power. Heating and cooling output may operate concurrently or alternately depending on need and system construction. Types of plants Hanasaari Power Plant, a coal-fired cogeneration power plant in Helsinki, Finland Topping cycle plants primarily produce electricity from a steam turbine. Partly expanded steam is then condensed in a heating condensor at a temperature level that is suitable e.g. district heating or water desalination. Bottoming cycle plants produce high temperature heat for industrial processes, then a waste heat recovery boiler feeds an electrical plant. Bottoming cycle plants are only used in industrial processes that require very high temperatures such as furnaces for glass and metal manufacturing, so they are less common. Large cogeneration systems provide heating water and power for an industrial site or an entire town. Common CHP plant types are: Gas turbine CHP plants using the waste heat in the flue gas of gas turbines. The fuel used is typically natural gas. Gas engine CHP plants use a reciprocating gas engine, which is generally more competitive than a gas turbine up to about 5 MW. The gaseous fuel used is normally natural gas. These plants are generally manufactured as fully packaged units that can be installed within a plantroom or external plant compound with simple connections to the site's gas supply, electrical distribution network and heating systems. Typical outputs and efficiencies see [6] Typical large example see [7] Biofuel engine CHP plants use an adapted reciprocating gas engine or diesel engine, depending upon which biofuel is being used, and are otherwise very similar in design to a Gas engine CHP plant. The advantage of using a biofuel is one of reduced fossil fuel consumption and thus reduced carbon emissions. These plants are generally manufactured as fully packaged units that can be installed within a plantroom or external plant compound with simple connections to the site's electrical distribution and heating systems. Another variant is the wood gasifier CHP plant whereby a wood pellet or wood chip biofuel is gasified in a zero oxygen high temperature environment; the resulting gas is then used to power the gas engine. Combined cycle power plants adapted for CHP Molten-carbonate fuel cells and solid oxide fuel cells have a hot exhaust, very suitable for heating. Steam turbine CHP plants that use the heating system as the steam condenser for the steam turbine Nuclear power plants, similar to other steam turbine power plants, can be fitted with extractions in the turbines to bleed partially expanded steam to a heating system. With a heating system temperature of 95 °C it is possible to extract about 10 MW heat for every MW electricity lost. With a temperature of 130 °C the gain is slightly smaller, about 7 MW for every MWe lost.[8] A review of cogeneration options is in [9] Czech research team proposed a "Teplator" system where heat from spent fuel rods is recovered for the purpose of residential heating.[10] Smaller cogeneration units may use a reciprocating engine or Stirling engine. The heat is removed from the exhaust and radiator. The systems are popular in small sizes because small gas and diesel engines are less expensive than small gas- or oil-fired steam-electric plants. Some cogeneration plants are fired by biomass,[11] or industrial and municipal solid waste (see incineration). Some CHP plants use waste gas as the fuel for electricity and heat generation. Waste gases can be gas from animal waste, landfill gas, gas from coal mines, sewage gas, and combustible industrial waste gas.[12] Some cogeneration plants combine gas and solar photovoltaic generation to further improve technical and environmental performance.[13] Such hybrid systems can be scaled down to the building level[14] and even individual homes.[15] MicroCHP Micro combined heat and power or 'Micro cogeneration" is a so-called distributed energy resource (DER). The installation is usually less than 5 kWe in a house or small business. Instead of burning fuel to merely heat space or water, some of the energy is converted to electricity in addition to heat. This electricity can be used within the home or business or, if permitted by the grid management, sold back into the electric power grid. Delta-ee consultants stated in 2013 that with 64% of global sales the fuel cell micro-combined heat and power passed the conventional systems in sales in 2012.[16] 20,000 units were sold in Japan in 2012 overall within the Ene Farm project. With a Lifetime of around 60,000 hours. For PEM fuel cell units, which shut down at night, this equates to an estimated lifetime of between ten and fifteen years.[17] For a price of $22,600 before installation.[18] For 2013 a state subsidy for 50,000 units is in place.[17] MicroCHP installations use five different technologies: microturbines, internal combustion engines, stirling engines, closed-cycle steam engines, and fuel cells. One author indicated in 2008 that MicroCHP based on Stirling engines is the most cost-effective of the so-called microgeneration technologies in abating carbon emissions.[19] A 2013 UK report from Ecuity Consulting stated that MCHP is the most cost-effective method of using gas to generate energy at the domestic level.[20][21] However, advances in reciprocation engine technology are adding efficiency to CHP plants, particularly in the biogas field. [22] As both MiniCHP and CHP have been shown to reduce emissions [23] they could play a large role in the field of CO_2 reduction from buildings, where more than 14% of emissions can be saved using CHP in buildings.[24] The University of Cambridge reported a cost-effective steam engine MicroCHP prototype in 2017 which has the potential to be commercially competitive in the following decades.[25] Quite recently, in some private homes, fuel cell micro-CHP plants can now be found, which can operate on hydrogen, or other fuels as natural gas or LPG.[26][27] When running on natural gas, it relies on steam reforming of natural gas to convert the natural gas to hydrogen prior to use in the fuel cell. This hence still emits CO_2 (see reaction) but (temporarily) running on this can be a good solution until the point where the hydrogen is starting to be distributed through the (natural gas) piping system. Another MicroCHP example is a natural gas or propane fueled Electricity Producing Condensing Furnace. It combines the fuel saving technique of cogeneration meaning producing electric power and useful heat from a single source of combustion. The condensing furnace is a forced-air gas system with a secondary heat exchanger that allows heat to be extracted from combustion products down to the ambient temperature along with recovering heat from the water vapor. The chimney is replaced by a water drain and vent to the side of the building. Trigeneration Trigeneration cycle A plant producing electricity, heat and cold is called a trigeneration[28] or polygeneration plant. Cogeneration systems linked to absorption chillers or adsorption chillers use waste heat for refrigeration.[29] Combined heat and power district heating See also: District heating In the United States, Consolidated Edison distributes 66 billion kilograms of 350 °F (177 °C) steam each year through its seven cogeneration plants to 100,000 buildings in Manhattan—the biggest steam district in the United States. The peak delivery is 10 million pounds per hour (or approximately 2.5 GW).[30][31] Industrial CHP Cogeneration is still common in pulp and paper mills, refineries and chemical plants. In this "industrial cogeneration/CHP", the heat is typically recovered at higher temperatures (above 100 °C) and used for process steam or drying duties. This is more valuable and flexible than low-grade waste heat, but there is a slight loss of power generation. The increased focus on sustainability has made industrial CHP more attractive, as it substantially reduces carbon footprint compared to generating steam or burning fuel on-site and importing electric power from the grid. Smaller industrial co-generation units have an output capacity of 5–25 MW and represent a viable off-grid option for a variety of remote applications to reduce carbon emissions. [32] Utility pressures versus self generated industrial Industrial cogeneration plants normally operate at much lower boiler pressures than utilities. Among the reasons are: 1.Cogeneration plants face possible contamination of returned condensate. Because boiler feed water from cogeneration plants has much lower return rates than 100% condensing power plants, industries usually have to treat proportionately more boiler make up water. Boiler feed water must be completely oxygen free and de-mineralized, and the higher the pressure the more critical the level of purity of the feed water.[5] 2.Utilities are typically larger scale power than industry, which helps offset the higher capital costs of high pressure. 3.Utilities are less likely to have sharp load swings than industrial operations, which deal with shutting down or starting up units that may represent a significant percent of either steam or power demand. Heat recovery steam generators A heat recovery steam generator (HRSG) is a steam boiler that uses hot exhaust gases from the gas turbines or reciprocating engines in a CHP plant to heat up water and generate steam. The steam, in turn, drives a steam turbine or is used in industrial processes that require heat. HRSGs used in the CHP industry are distinguished from conventional steam generators by the following main features: The HRSG is designed based upon the specific features of the gas turbine or reciprocating engine that it will be coupled to. Since the exhaust gas temperature is relatively low, heat transmission is accomplished mainly through convection. The exhaust gas velocity is limited by the need to keep head losses down. Thus, the transmission coefficient is low, which calls for a large heating surface area. Since the temperature difference between the hot gases and the fluid to be heated (steam or water) is low, and with the heat transmission coefficient being low as well, the evaporator and economizer are designed with plate fin heat exchangers. Cogeneration using biomass Biomass refers to any plant or animal matter in which it is possible to be reused as a source of heat or electricity, such as sugarcane, vegetable oils, wood, organic waste and residues from the food or agricultural industries. Brazil is now considered a world reference in terms of energy generation from biomass.[33] A growing sector in the use of biomass for power generation is the sugar and alcohol sector, which mainly uses sugarcane bagasse as fuel for thermal and electric power generation.[34] Power cogeneration in the sugar and alcohol sector In the sugarcane industry, cogeneration is fueled by the bagasse residue of sugar refining, which is burned to produce steam. Some steam can be sent through a turbine that turns a generator, producing electric power.[35] Energy cogeneration in sugarcane industries located in Brazil is a practice that has been growing in last years. With the adoption of energy cogeneration in the sugar and alcohol sector, the sugarcane industries are able to supply the electric energy demand needed to operate, and generate a surplus that can be commercialized.[36][37] Advantages of the cogeneration using sugarcane bagasse In comparison with the electric power generation by means of fossil fuel-based thermoelectric plants, such as natural gas, the energy generation using sugarcane bagasse has environmental advantages due to the reduction of CO_2 emissions.[38] In addition to the environmental advantages, cogeneration using sugarcane bagasse presents advantages in terms of efficiency comparing to thermoelectric generation, through the final destination of the energy produced. While in thermoelectric generation, part of the heat produced is lost, in cogeneration this heat has the possibility of being used in the production processes, increasing the overall efficiency of the process.[38] Disadvantages of the cogeneration using sugarcane bagasse In sugarcane cultivation, is usually used potassium source's containing high concentration of chlorine, such as potassium chloride (KCl). Considering that KCl is applied in huge quantities, sugarcane ends up absorbing high concentrations of chlorine.[39] Due to this absorption, when the sugarcane bagasse is burned in the power cogeneration, dioxins [39] and methyl chloride [40] ends up being emitted. In the case of dioxins, these substances are considered very toxic and cancerous.[41][42][43] In the case of methyl chloride, when this substance is emitted and reaches the stratosphere, it ends up being very harmful for the ozone layer, since chlorine when combined with the ozone molecule generates a catalytic reaction leading to the breakdown of ozone links.[40] After each reaction, chlorine starts a destructive cycle with another ozone molecule. In this way, a single chlorine atom can destroy thousands of ozone molecules. As these molecules are being broken, they are unable to absorb the ultraviolet rays. As a result, the UV radiation is more intense on Earth and there is a worsening of global warming.[40] Comparison with a heat pump A heat pump may be compared with a CHP unit as follows. If, to supply thermal energy, the exhaust steam from the turbo-generator must be taken at a higher temperature than the system would produce most electricity at, the lost electrical generation is as if a heat pump were used to provide the same heat by taking electrical power from the generator running at lower output temperature and higher efficiency.[44] Typically for every unit of electrical power lost, then about 6 units of heat are made available at about 90 °C (194 °F). Thus CHP has an effective Coefficient of Performance (COP) compared to a heat pump of 6.[45] However, for a remotely operated heat pump, losses in the electrical distribution network would need to be considered, of the order of 6%. Because the losses are proportional to the square of the current, during peak periods losses are much higher than this and it is likely that widespread (i.e. citywide application of heat pumps) would cause overloading of the distribution and transmission grids unless they were substantially reinforced. It is also possible to run a heat driven operation combined with a heat pump, where the excess electricity (as heat demand is the defining factor on use[clarification needed]) is used to drive a heat pump. As heat demand increases, more electricity is generated to drive the heat pump, with the waste heat also heating the heating fluid. As the efficiency of heat pumps depends on the difference between hot end and cold end temperature (efficiency rises as the difference decreases) it may be worthwhile to combine even relatively low grade waste heat otherwise unsuitable for home heating with heat pumps. For example, a large enough reservoir of cooling water at 15 °C (59 °F) can significantly improve efficiency of heat pumps drawing from such a reservoir compared to air source heat pumps drawing from cold air during a −20 °C (−4 °F) night. In the summer when there's both demand for air conditioning and warm water, the same water may even serve as both a "dump" for the waste heat rejected by a/c units and as a "source" for heat pumps providing warm water. Those considerations are behind what is sometimes called "cold district heating" using a "heat" source whose temperature is well below those usually employed in district heating. [46] Distributed generation Most industrial countries generate the majority of their electrical power needs in large centralized facilities with capacity for large electrical power output. These plants benefit from economy of scale, but may need to transmit electricity across long distances causing transmission losses. Cogeneration or trigeneration production is subject to limitations in the local demand and thus may sometimes need to reduce (e.g., heat or cooling production to match the demand). An example of cogeneration with trigeneration applications in a major city is the New York City steam system. Thermal efficiency Every heat engine is subject to the theoretical efficiency limits of the Carnot cycle or subset Rankine cycle in the case of steam turbine power plants or Brayton cycle in gas turbine with steam turbine plants. Most of the efficiency loss with steam power generation is associated with the latent heat of vaporization of steam that is not recovered when a turbine exhausts its low temperature and pressure steam to a condenser. (Typical steam to condenser would be at a few millimeters absolute pressure and on the order of 5 °C (41 °F) hotter than the cooling water temperature, depending on the condenser capacity.) In cogeneration this steam exits the turbine at a higher temperature where it may be used for process heat, building heat or cooling with an absorption chiller. The majority of this heat is from the latent heat of vaporization when the steam condenses. Thermal efficiency in a cogeneration system is defined as: Where: = Thermal efficiency = Total work output by all systems = Total heat input into the system Heat output may also be used for cooling (for example, in summer), thanks to an absorption chiller. If cooling is achieved in the same time, thermal efficiency in a trigeneration system is defined as: Where: = Thermal efficiency = Total work output by all systems = Total heat input into the system Typical cogeneration models have losses as in any system. The energy distribution below is represented as a percent of total input energy:[47] Electricity = 45% Heat + Cooling = 40% Heat losses = 13% Electrical line losses = 2% Conventional central coal- or nuclear-powered power stations convert about 33–45% of their input heat to electricity.[48][5] Brayton cycle power plants operate at up to 60% efficiency. In the case of conventional power plants, approximately 10-15% of this heat is lost up the stack of the boiler. Most of the remaining heat emerges from the turbines as low-grade waste heat with no significant local uses, so it is usually rejected to the environment, typically to cooling water passing through a condenser.[5] Because turbine exhaust is normally just above ambient temperature, some potential power generation is sacrificed in rejecting higher-temperature steam from the turbine for cogeneration purposes.[49] For cogeneration to be practical power generation and end use of heat must be in relatively close proximity (<2 km typically). Even though the efficiency of a small distributed electrical generator may be lower than a large central power plant, the use of its waste heat for local heating and cooling can result in an overall use of the primary fuel supply as great as 80%.[48] This provides substantial financial and environmental benefits. Costs See also: Cost of electricity by source Typically, for a gas-fired plant the fully installed cost per kW electrical is around £400/kW (US$577), which is comparable with large central power stations.[50] History Cogeneration in Europe A cogeneration thermal power plant in Ferrera Erbognone (PV), Italy This section needs to be updated. Please help update this article to reflect recent events or newly available information. (May 2021) The EU has actively incorporated cogeneration into its energy policy via the CHP Directive. In September 2008 at a hearing of the European Parliament's Urban Lodgment Intergroup, Energy Commissioner Andris Piebalgs is quoted as saying, "security of supply really starts with energy efficiency."[51] Energy efficiency and cogeneration are recognized in the opening paragraphs of the European Union's Cogeneration Directive 2004/08/EC. This directive intends to support cogeneration and establish a method for calculating cogeneration abilities per country. The development of cogeneration has been very uneven over the years and has been dominated throughout the last decades by national circumstances. The European Union generates 11% of its electricity using cogeneration.[52] However, there is large difference between Member States with variations of the energy savings between 2% and 60%. Europe has the three countries with the world's most intensive cogeneration economies: Denmark, the Netherlands and Finland.[53] Of the 28.46 TWh of electrical power generated by conventional thermal power plants in Finland in 2012, 81.80% was cogeneration.[54] Other European countries are also making great efforts to increase efficiency. Germany reported that at present, over 50% of the country's total electricity demand could be provided through cogeneration. So far, Germany has set the target to double its electricity cogeneration from 12.5% of the country's electricity to 25% of the country's electricity by 2020 and has passed supporting legislation accordingly.[55] The UK is also actively supporting combined heat and power. In light of UK's goal to achieve a 60% reduction in carbon dioxide emissions by 2050, the government has set the target to source at least 15% of its government electricity use from CHP by 2010.[56] Other UK measures to encourage CHP growth are financial incentives, grant support, a greater regulatory framework, and government leadership and partnership. According to the IEA 2008 modeling of cogeneration expansion for the G8 countries, the expansion of cogeneration in France, Germany, Italy and the UK alone would effectively double the existing primary fuel savings by 2030. This would increase Europe's savings from today's 155.69 Twh to 465 Twh in 2030. It would also result in a 16% to 29% increase in each country's total cogenerated electricity by 2030. Governments are being assisted in their CHP endeavors by organizations like COGEN Europe who serve as an information hub for the most recent updates within Europe's energy policy. COGEN is Europe's umbrella organization representing the interests of the cogeneration industry. The European public–private partnership Fuel Cells and Hydrogen Joint Undertaking Seventh Framework Programme project ene.field deploys in 2017[57] up 1,000 residential fuel cell Combined Heat and Power (micro-CHP) installations in 12 states. Per 2012 the first 2 installations have taken place.[58][59][60] Cogeneration in the United Kingdom In the United Kingdom, the Combined Heat and Power Quality Assurance scheme regulates the combined production of heat and power. It was introduced in 1996. It defines, through calculation of inputs and outputs, "Good Quality CHP" in terms of the achievement of primary energy savings against conventional separate generation of heat and electricity. Compliance with Combined Heat and Power Quality Assurance is required for cogeneration installations to be eligible for government subsidies and tax incentives.[61] Cogeneration in the United States The 250 MW Kendall Cogeneration Station plant in Cambridge, Massachusetts Perhaps the first modern use of energy recycling was done by Thomas Edison. His 1882 Pearl Street Station, the world's first commercial power plant, was a combined heat and power plant, producing both electricity and thermal energy while using waste heat to warm neighboring buildings.[62] Recycling allowed Edison's plant to achieve approximately 50 percent efficiency. By the early 1900s, regulations emerged to promote rural electrification through the construction of centralized plants managed by regional utilities. These regulations not only promoted electrification throughout the countryside, but they also discouraged decentralized power generation, such as cogeneration. By 1978, Congress recognized that efficiency at central power plants had stagnated and sought to encourage improved efficiency with the Public Utility Regulatory Policies Act (PURPA), which encouraged utilities to buy power from other energy producers. Cogeneration plants proliferated, soon producing about 8% of all energy in the United States.[63] However, the bill left implementation and enforcement up to individual states, resulting in little or nothing being done in many parts of the country.[citation needed] The United States Department of Energy has an aggressive goal of having CHP constitute 20% of generation capacity by 2030.[citation needed] Eight Clean Energy Application Centers[64] have been established across the nation. Their mission is to develop the required technology application knowledge and educational infrastructure necessary to lead "clean energy" (combined heat and power, waste heat recovery, and district energy) technologies as viable energy options and reduce any perceived risks associated with their implementation. The focus of the Application Centers is to provide an outreach and technology deployment program for end users, policymakers, utilities, and industry stakeholders. High electric rates in New England and the Middle Atlantic make these areas of the United States the most beneficial for cogeneration.[65][66] ISBN 978-0-8493-2274-7 v t e Electricity delivery Concepts Automatic generation control Backfeeding Base load Demand factor Droop speed control Electric power Electric power quality Electrical fault Energy demand management Energy return on investment Grid code Grid energy storage Grid strength Home energy storage Load-following Merit order Nameplate capacity Peak demand Power factor Power-flow study Repowering Utility frequency Variability Vehicle-to-grid Sources Non-renewable Fossil fuel power station oCoal oNatural gas oOil shale oPetroleum Nuclear Renewable Biofuel Biogas Biomass Geothermal Hydro Marine oCurrent oOsmotic oThermal oTidal oWave Solar Sustainable biofuel Wind Generation AC power Cogeneration Combined cycle Cooling tower Induction generator Micro CHP Microgeneration Rankine cycle Three-phase electric power Virtual power plant Transmission and distribution Demand response Distributed generation Dynamic demand Electric power

distribution Electric power system Electric power transmission Electrical busbar system Electrical grid Electrical substation Electricity retailing High-voltage direct current High-voltage shore connection Interconnector Load management Mains electricity by country Overhead power line Power station Pumped hydro Single-wire earth return Smart grid Super grid Transformer Transmission system operator (TSO) Transmission tower Utility pole Failure modes Black start Brownout Cascading failure Power outage oRolling blackout Protective devices Arc-fault circuit interrupter Circuit breaker oEarth-leakage oSulfur hexafluoride Generator interlock kit Numerical relay Power system protection Protective relay Residual-current device (GFI) Economics and policies Availability factor Capacity factor Carbon offsets and credits Cost of electricity by source Energy subsidies Environmental tax Feed-in tariff Fossil fuel phase-out Load factor Net metering Pigouvian tax Renewable Energy Certificates Renewable energy commercialization Renewable Energy Payments Spark/Dark/Quark/Bark spread Statistics and production Electric energy consumption List of electricity sectors Contents (Top) Types Protecting the power system from outages Protecting computer systems from power outages Restoring power after a wide-area outage Blackout inevitability and electric sustainability o Self-organized criticality o OPA model o Mitigation of power outage frequency Key performance indicators See also References External links Power outage Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia This article is about accidental power failures. For intentionally engineered ones, see rolling blackout. For other uses, see Power Outage (disambiguation). "Power cut" redirects here. For the 2012 Punjabi film, see Power Cut. Vehicle lights provided the only illumination during the 2009 Ecuador electricity crisis. A power outage, also called a powercut, a power out, a power failure, a power blackout, a power loss, a blackout or a power drought — is the loss of the electrical power network supply to an end user. There are many causes of power failures in an electricity network. Examples of these causes include faults at power stations, damage to electric transmission lines, substations or other parts of the distribution system, a short circuit, cascading failure, fuse or circuit breaker operation. Power failures are particularly critical at sites where the environment and public safety are at risk. Institutions such as hospitals, sewage treatment plants, and mines will usually have backup power sources such as standby generators, which will automatically start up when electrical power is lost. Other critical systems, such as telecommunication, are also required to have emergency power. The battery room of a telephone exchange usually has arrays of lead–acid batteries for backup and also a socket for connecting a generator during extended periods of outage. During a power outage, there is a disruption in the supply of electricity, resulting in a loss of power to homes, businesses, and other facilities. Power outages can occur for various reasons, including severe weather conditions (e.g. storms, hurricanes, or blizzards), earthquakes, equipment failure, grid overload, or planned maintenance. Types Blackout Transient fault Power outages are categorized into three different phenomena, relating to the duration and effect of the outage: A transient fault is a loss of power typically caused by a fault on a power line, e.g. a short circuit or flashover. Power is automatically restored once the fault is cleared. A brownout is a drop in voltage in an electrical power supply. The term brownout comes from the dimming experienced by incandescent lighting when the voltage sags. Brownouts can cause poor performance of equipment or even incorrect operation. A blackout is the total loss of power to a wider area and of long duration.[1] It is the most severe form of power outage that can occur. Blackouts which result or result in power stations tripping are particularly difficult to recover from quickly. Outages may last from a few minutes to a few weeks depending on the nature of the blackout and the configuration of the electrical network. Rolling blackouts occur when demand for electricity exceeds supply, and allow some customers to receive power at the required voltage at the expense of other customers who get no power at all. They are a common occurrence in developing countries, and may be scheduled in advance or occur without warning. They have also occurred in developed countries, for example in the California electricity crisis of 2000–2001, when government deregulation destabilized the wholesale electricity market. Blackouts are also used as a public safety measure, such as to prevent a gas leak from catching fire (for example, power was cut to several towns in response to the Merrimack Valley gas explosions), or to prevent wildfires around poorly maintained transmission lines (such as during the 2019 California power shutoffs). Protecting the power system from outages Tree limbs creating a short circuit in power lines during a storm. This typically results in a power outage in the area supplied by these lines In power supply networks, the power generation and the electrical load (demand) must be very close to equal every second to avoid overloading of network components, which can severely damage them. Protective relays and fuses are used to automatically detect overloads and to disconnect circuits at risk of damage. Under certain conditions, a network component shutting down can cause current fluctuations in neighboring segments of the network leading to a cascading failure of a larger section of the network. This may range from a building, to a block, to an entire city, to an entire electrical grid. Modern power systems are designed to be resistant to this sort of cascading failure, but it may be unavoidable (see below). Moreover, since there is no short-term economic benefit to preventing rare large-scale failures, researchers have expressed concern that there is a tendency to erode the resilience of the network over time, which is only corrected after a major failure occurs.[citation needed] In a 2003 publication, Carreras and co-authors claimed that reducing the likelihood of small outages only increases the likelihood of larger ones.[2] In that case, the short-term economic benefit of keeping the individual customer happy increases the likelihood of large-scale blackouts. The Senate Committee on Energy and Natural Resources held a hearing in October 2018 to examine "black start", the process of restoring electricity after a system-wide power loss. The hearing's purpose was for Congress to learn about what the backup plans are in the electric utility industry in the case that the electric grid is damaged. Threats to the electrical grid include cyberattacks, solar storms, and severe weather, among others. For example, the "Northeast Blackout of 2003" was caused when overgrown trees touched high-voltage power lines. Around 55 million people in the U.S. and Canada lost power, and restoring it cost around $6 billion.[3] Protecting computer systems from power outages Computer systems and other electronic devices containing logic circuitry are susceptible to data loss or hardware damage that can be caused by the sudden loss of power. These can include data networking equipment, video projectors, alarm systems as well as computers. To protect computer systems against this, the use of an uninterruptible power supply or 'UPS' can provide a constant flow of electricity if a primary power supply becomes unavailable for a short period of time. To protect against surges (events where voltages increase for a few seconds), which can damage hardware when power is restored, a special device called a surge protector that absorbs the excess voltage can be used. Restoring power after a wide-area outage Restoring power after a wide-area outage can be difficult, as power stations need to be brought back online. Normally, this is done with the help of power from the rest of the grid. In the total absence of grid power, a so-called black start needs to be performed to bootstrap the power grid into operation. The means of doing so will depend greatly on local circumstances and operational policies, but typically transmission utilities will establish localized 'power islands' which are then progressively coupled together. To maintain supply frequencies within tolerable limits during this process, demand must be reconnected at the same pace that generation is restored, requiring close coordination between power stations, transmission and distribution organizations. Blackout inevitability and electric sustainability Comparison of duration of power outages (SAIDI value), in 2014. Self-organized criticality Further information: Self-organized criticality control It has been argued on the basis of historical data[4] and computer modeling[5][6] that power grids are self-organized critical systems. These systems exhibit unavoidable[7] disturbances of all sizes, up to the size of the entire system. This phenomenon has been attributed to steadily increasing demand/load, the economics of running a power company, and the limits of modern engineering.[8] While blackout frequency has been shown to be reduced by operating it further from its critical point, it generally is not economically feasible, causing providers to increase the average load over time or upgrade less often resulting in the grid moving itself closer to its critical point. Conversely, a system past the critical point will experience too many blackouts leading to system-wide upgrades moving it back below the critical point. The term critical point of the system is used here in the sense of statistical physics and nonlinear dynamics, representing the point where a system undergoes a phase transition; in this case the transition from a steady reliable grid with few cascading failures to a very sporadic unreliable grid with common cascading failures. Near the critical point the relationship between blackout frequency and size follows a power-law distribution.[6][8] Cascading failure becomes much more common close to this critical point. The power-law relationship is seen in both historical data and model systems.[8] The practice of operating these systems much closer to their maximum capacity leads to magnified effects of random, unavoidable disturbances due to aging, weather, human interaction etc. While near the critical point, these failures have a greater effect on the surrounding components due to individual components carrying a larger load. This results in the larger load from the failing component having to be redistributed in larger quantities across the system, making it more likely for additional components not directly affected by the disturbance to fail, igniting costly and dangerous cascading failures.[8] These initial disturbances causing blackouts are all the more unexpected and unavoidable due to actions of the power suppliers to prevent obvious disturbances (cutting back trees, separating lines in windy areas, replacing aging components etc.). The complexity of most power grids often makes the initial cause of a blackout extremely hard to identify. Leaders are dismissive of system theories that conclude that blackouts are inevitable, but do agree that the basic operation of the grid must be changed. The Electric Power Research Institute champions the use of smart grid features such as power control devices employing advanced sensors to coordinate the grid.[9] Others advocate greater use of electronically controlled high-voltage direct current (HVDC) firebreaks to prevent disturbances from cascading across AC lines in a wide area grid.[10] OPA model In 2002, researchers at Oak Ridge National Laboratory (ORNL), Power System Engineering Research Center of the University of Wisconsin (PSerc),[11] and the University of Alaska Fairbanks proposed a mathematical model for the behavior of electrical distribution systems.[12][13] This model has become known as the OPA model, a reference to the names of the authors' institutions. OPA is a cascading failure model. Other cascading failure models include Manchester, Hidden failure, CASCADE, and Branching.[14] The OPA model was quantitatively compared with a complex networks model of a cascading failure – Crucitti–Latora–Marchiori (CLM) model,[15] showing that both models exhibit similar phase transitions in the average network damage (load shed/demand in OPA, path damage in CLM), with respect to transmission capacity.[16] Mitigation of power outage frequency The effects of trying to mitigate cascading failures near the critical point in an economically feasible fashion are often shown to not be beneficial and often even detrimental. Four mitigation methods have been tested using the OPA blackout model:[2] Increase critical number of failures causing cascading blackouts – Shown to decrease the frequency of smaller blackouts but increase that of larger blackouts. Increase individual power line max load – Shown to increase the frequency of smaller blackouts and decrease that of larger blackouts. Combination of increasing critical number and max load of lines – Shown to have no significant effect on either size of blackout. The resulting minor reduction in the frequency of blackouts is projected to not be worth the cost of the implementation. Increase the excess power available to the grid – Shown to decrease the frequency of smaller blackouts but increase that of larger blackouts. In addition to the finding of each mitigation strategy having a cost-benefit relationship with regards to frequency of small and large blackouts, the total number of blackout events was not significantly reduced by any of the above-mentioned mitigation measures.[2] A complex network-based model to control large cascading failures (blackouts) using local information only was proposed by A. E. Motter.[17] In 2015, one of the solutions proposed to reduce the impact of power outage was introduced by M. S. A smart meter is an electronic device that records information—such as consumption of electric energy, voltage levels, current, and power factor—and communicates the information to the consumer and electricity suppliers. Advanced metering infrastructure (AMI) differs from automatic meter reading (AMR) in that it enables two-way communication between the meter and the supplier. Description The term smart meter often refers to an electricity meter, but it also may mean a device measuring natural gas, water or district heating consumption.[1][2] More generally, a smart meter is an electronic device that records information such as consumption of electric energy, voltage levels, current, and power factor. Smart meters communicate the information to the consumer for greater clarity of consumption behavior, and electricity suppliers for system monitoring and customer billing. Smart meters typically record energy near real-time, and report regularly, in short intervals throughout the day.[3] Smart meters enable two-way communication between the meter and the central system. Smart meters may be part of a smart grid, but do not themselves constitute a smart grid.[4] Such an advanced metering infrastructure (AMI) differs from automatic meter reading (AMR) in that it enables two-way communication between the meter and the supplier. Communications from the meter to the network may be wireless, or via fixed wired connections such as power line carrier (PLC). Wireless communication options in common use include cellular communications, Wi-Fi (readily available), wireless ad hoc networks over Wi-Fi, wireless mesh networks, low power long-range wireless (LoRa), Wize (high radio penetration rate, open, using the frequency 169 MHz) Zigbee (low power, low data rate wireless), and Wi-SUN (Smart Utility Networks). Similar meters, usually referred to as interval or time-of-use meters, have existed for years, but smart meters usually involve real-time or near real-time sensors, power outage notification, and power quality monitoring. These additional features are more than simple automated meter reading (AMR). They are similar in many respects to Advanced Metering Infrastructure (AMI) meters. Interval and time-of-use meters historically have been installed to measure commercial and industrial customers, but may not have automatic reading.[citation needed] Research by the UK consumer group Which?, showed that as many as one in three confuse smart meters with energy monitors, also known as in-home display monitors.[5][when?] History In 1972, Theodore Paraskevakos, while working with Boeing in Huntsville, Alabama, developed a sensor monitoring system that used digital transmission for security, fire, and medical alarm systems as well as meter reading capabilities. This technology was a spin-off from the automatic telephone line identification system, now known as Caller ID. In 1974, Paraskevakos was awarded a U.S. patent for this technology.[6] In 1977, he launched Metretek, Inc.,[7] which developed and produced the first smart meters.[8] Since this system was developed pre-Internet, Metretek utilized the IBM series 1 mini-computer. For this approach, Paraskevakos and Metretek were awarded multiple patents.[9] The installed base of smart meters in Europe at the end of 2008 was about 39 million units, according to analyst firm Berg Insight.[10] Globally, Pike Research found that smart meter shipments were 17.4 million units for the first quarter of 2011.[11] Visiongain determined that the value of the global smart meter market would reach US$7 billion in 2012.[12] H.M. Zahid Iqbal, M. Waseem, and Dr. Tahir Mahmood, researchers of University of Engineering & Technology Taxila, Pakistan, introduced the concept of Smart Energy Meters in 2013. Their article, "Automatic Energy Meter Reading using Smart Energy Meter" outlined the key features of Smart Energy Meter including Automatic remote meter reading via GSM for utility companies and customers, Real-time monitoring of a customer's running load, Remote disconnection and reconnection of customer connections by the utility company and Convenient billing, eliminating the need of meter readers to physically visit the customers for billing. As of January 2018, over 99 million electricity meters were deployed across the European Union, with an estimated 24 million more to be installed by the end of 2020. The European Commission DG Energy estimates the 2020 installed base to have required €18.8 billion in investment, growing to €40.7 billion by 2030, with a total deployment of 266 million smart meters.[13] By the end of 2018, the U.S. had over 86 million smart meters installed.[14] In 2017, there were 665 million smart meters installed globally.[15] Revenue generation is expected to grow from $12.8 billion in 2017 to $20 billion by 2022.[16] Purpose Since the inception of electricity deregulation and market-driven pricing throughout the world, utilities have been looking for a means to match consumption with generation. Non-smart electrical and gas meters only measure total consumption, providing no information of when the energy was consumed.[17] Smart meters provide a way of measuring electricity consumption in near real-time. This allows utility companies to charge different prices for consumption according to the time of day and the season.[18] It also facilitates more accurate cash-flow models for utilities. Since smart meters can be read remotely, labor costs are reduced for utilities. Smart metering offers potential benefits to customers. These include, a) an end to estimated bills, which are a major source of complaints for many customers b) a tool to help consumers better manage their energy purchases—smart meters with a display outside their homes could provide up-to-date information on gas and electricity consumption and in doing so help people to manage their energy use and reduce their energy bills. With regards to consumption reduction, this is critical for understanding the benefits of smart meters because the relatively small percentage benefits in terms of savings are multiplied by millions of users.[19] Smart meters for water consumption can also provide detailed and timely information about customer water use and early notification of possible water leaks in their premises.[20] Electricity pricing usually peaks at certain predictable times of the day and the season. In particular, if generation is constrained, prices can rise if power from other jurisdictions or more costly generation is brought online. Proponents assert that billing customers at a higher rate for peak times encourages consumers to adjust their consumption habits to be more responsive to market prices and assert further, that regulatory and market design agencies hope these "price signals" could delay the construction of additional generation or at least the purchase of energy from higher-priced sources, thereby controlling the steady and rapid increase of electricity prices.[citation needed] An academic study based on existing trials showed that homeowners' electricity consumption on average is reduced by approximately 3-5% when provided with real-time feedback.[21] Another advantage of smart meters that benefits both customers and the utility is the monitoring capability they provide for the whole electrical system. As part of an AMI, utilities can use the real-time data from smart meters measurements related to current, voltage, and power factor to detect system disruptions more quickly, allowing immediate corrective action to minimize customer impact such as blackouts. Smart meters also help utilities understand the power grid needs with more granularity than legacy meters. This greater understanding facilitates system planning to meet customer energy needs while reducing the likelihood of additional infrastructure investments, which eliminates unnecessary spending or energy cost increases.[22] Though the task of meeting national electricity demand with accurate supply is becoming ever more challenging as intermittent renewable generation sources make up a greater proportion of the energy mix, the real-time data provided by smart meters allow grid operators to integrate renewable energy onto the grid in order to balance the networks. As a result, smart meters are considered an essential technology to the decarbonisation of the energy system.[23] Advanced metering infrastructure Advanced metering infrastructure (AMI) refers to systems that measure, collect, and analyze energy usage, and communicate with metering devices such as electricity meters, gas meters, heat meters, and water meters, either on request or on a schedule. These systems include hardware, software, communications, consumer energy displays and controllers, customer associated systems, meter data management software, and supplier business systems. Government agencies and utilities are turning toward advanced metering infrastructure (AMI) systems as part of larger "smart grid" initiatives. AMI extends automatic meter reading (AMR) technology by providing two-way meter communications, allowing commands to be sent toward the home for multiple purposes, including time-based pricing information, demand-response actions, or remote service disconnects. Wireless technologies are critical elements of the neighborhood network, aggregating a mesh configuration of up to thousands of meters for back haul to the utility's IT headquarters. The network between the measurement devices and business systems allows the collection and distribution of information to customers, suppliers, utility companies, and service providers. This enables these businesses to participate in demand response services. Consumers can use the information provided by the system to change their normal consumption patterns to take advantage of lower prices. Pricing can be used to curb the growth of peak demand consumption. AMI differs from traditional automatic meter reading (AMR) in that it enables two-way communications with the meter. Systems only capable of meter readings do not qualify as AMI systems.[24] Typical smart meter ami diagram AMI implementation relies on four key components: Physical Layer Connectivity, which establishes connections between smart meters and networks, Communication Protocols to ensure secure and efficient data transmission, Server Infrastructure, which consists of centralized or distributed servers to store, process, and manage data for billing, monitoring, and demand response; and Data Analysis, where analytical tools provide insights, load forecasting, and anomaly detection for optimized energy management. Together, these components help utilities and consumers monitor and manage energy use efficiently, supporting smarter grid management.[25] Physical Layer Connectivity Communication is a cornerstone of smart meter technology, enabling reliable and secure data transmission to central systems. However, the diversity of environments in which smart meters operate presents significant challenges. Solutions to these challenges encompass a range of communication methods[26] including Power-line communication[27] (PLC), Cellular network,[28] Wireless mesh network,[29] Short-range,[29] and satellite[citation needed]: Power-line communication for Smart Metering Power Line Communication (PLC)[a] stands out among smart metering connectivity technologies because it leverages existing electrical power infrastructure for data transmission. Unlike cellular, radio-frequency (RF), or Wi-Fi-based solutions, PLC does not require building or maintaining separate communication networks, making it inherently more cost-effective and easier to scale. Two major PLC standards in smart metering are G3-PLC and the PRIME Alliance protocol.[27] G3-PLC supports IPv6-based communications and adaptive data rates, providing robust performance even in noisy environments, while PRIME (PoweRline Intelligent Metering Evolution) focuses on efficient, high-speed communication with low-cost implementation. PLC-based smart metering is deployed extensively in regions [30][31] like Europe, South America, and parts of Asia where dense infrastructure supports its use. Utilities favor PLC for its reliability in urban environments and for connecting large numbers of meters within smart grid networks. An important feature of G3-PLC and PRIME is their ability to enable mesh networking (also called multi-hop), where smart meters act as repeaters for other meters in the network. This functionality allows meters to relay data from neighboring meters to ensure that the information reaches the Data Concentrator Unit (DCU), even if direct communication is not possible due to distance or signal obstructions. This approach enhances network reliability and coverage, particularly in dense urban environments or geographically challenging areas.[32] Cellular Network (GPRS, NB-IoT, LTE-M): "Cellular technologies are highly scalable and secure. With national coverage, cellular connectivity can support a large number of meters in densely populated areas as well as reach those in remote locations."[28] Wireless mesh network (e.g. Wirepas[33] and Wi-Sun[34]): Ideal for urban areas, where devices can relay data to optimize coverage and reliability. It is mostly used for Water Meter and Gas Meter Short-range: such as Wireless M-Bus (WMBUS) are commonly used in smart metering applications to enable reliable, low-power communication between utility meters and local data collectors within buildings or neighborhoods. Hybrid PLC/RF PRIME and G3-PLC standards defines an integrated approach for seamless integration of PLC and wireless communication, enhancing reliability and flexibility in smart grids.[35] Additional options, such as Wi-Fi[citation needed] and internet-based networks, are also in use. However, no single communication solution is universally optimal. The challenges faced by rural utilities differ significantly from those of urban counterparts or utilities in remote, mountainous, or poorly serviced areas. Smart meters often extend their functionality through integration into Home Area Networks (HANs). These networks enable communication within the household and may include: In-Premises Displays: Providing real-time energy usage insights for consumers. Hubs: Interfacing multiple meters with the central head-end system.[citation needed] Technologies used in HANs vary globally but typically include PLC, wireless ad hoc networks, and Zigbee. By leveraging appropriate connectivity solutions, smart meters can address diverse environmental and infrastructural needs while delivering seamless communication and enhanced functionality.[citation needed] Smart meters used as a gateway for water and gas meters Electricity smart meters start to be utilized as gateways for gas and water meters, creating integrated smart metering systems.[36] In this configuration, gas and water meters communicate with the electricity meter using Wireless M-Bus (Wireless Meter-Bus), a European standard (EN 13757-4) designed for secure and efficient data transmission between utility meters and data collectors. The electricity meter then aggregates this data and transmits it to the central utility network via Power Line Communication (PLC), which leverages existing electrical wiring for data transfer. Communication Protocols Smart meter communication protocols are essential for enabling reliable, efficient, and secure data exchange between meters, utilities, and other components of advanced metering infrastructure (AMI). These protocols address the diverse requirements of global markets, supporting various communication methods, from optical ports and serial connections to power line communication (PLC) and wireless networks. Below is an overview of key protocols, including ANSI standards widely used in North America, IEC protocols prevalent in Europe, the globally recognized OSGP for smart grid applications, and the PLC-focused Meters and More, each designed to meet specific needs in energy monitoring and management. Typical communication stacks from Smart Meter to DC IEC 62056 "IEC 62056 is the most widely adopted protocol"[37] for smart meter communication, enabling reliable, two-way data exchange within Advanced Metering Infrastructure (AMI) systems. It encompasses the DLMS/COSEM protocol for structuring and managing metering data. "It is widely used because of its flexibility, scalability, and ability to support different communication media such as Power Line Communication (PLC), TCP/IP, and wireless networks.".[37] It also supports data transmission over serial connections using ASCII or binary formats, with physical media options such as modulated light (via LED and photodiode) or wired connections (typically EIA-485).[38] ANSI C12.18 ANSI C12.18 is an ANSI Standard that describes a protocol used for two-way communications with a meter, mostly used in North American markets. The C12.18 Standard is written specifically for meter communications via an ANSI Type 2 Optical Port, and specifies lower-level protocol details. ANSI C12.19 specifies the data tables that are used. ANSI C12.21 is an extension of C12.18 written for modem instead of optical communications, so it is better suited to automatic meter reading. ANSI C12.22 is the communication protocol for remote communications.[39] OSGP The Open Smart Grid Protocol (OSGP) is a family of specifications published by the European Telecommunications Standards Institute (ETSI) used in conjunction with the ISO/IEC 14908 control networking standard for smart metering and smart grid applications. Millions of smart meters based on OSGP are deployed worldwide.[40] On July 15, 2015, the OSGP Alliance announced the release of a new security protocol (OSGP-AES-128-PSK) and its availability from OSGP vendors.[41] This deprecated the original OSGP-RC4-PSK security protocol which had been identified to be vulnerable.[42][43] Meters and More "Meters and More was created in 2010 from the coordinated work between Enel and Endesa to adopt, maintain and evolve the field-proven Meters and More open communication protocol for smart grid solutions." .[44] In 2010, the Meters and More Association was established to promote the protocol globally, ensuring interoperability and efficiency in power line communication (PLC)-based smart metering systems. Meters and More is an open communication protocol designed for advanced metering infrastructure (AMI). It facilitates reliable, high-speed data exchange over PLC networks, focusing on energy monitoring, demand response, and secure two-way communication between utilities and consumers. Unlike DLMS/COSEM, which is a globally standardized and versatile protocol supporting multiple utilities (electricity, gas, and water), Meters and More is tailored specifically for PLC-based systems, emphasizing efficiency, reliability, and ease of deployment in electricity metering. There is a growing trend toward the use of TCP/IP technology as a common communication platform for Smart Meter applications, so that utilities can deploy multiple communication systems, while using IP technology as a common management platform.[45][46] A universal metering interface would allow for development and mass production of smart meters and smart grid devices prior to the communication standards being set, and then for the relevant communication modules to be easily added or switched when they are. This would lower the risk of investing in the wrong standard as well as permit a single product to be used globally even if regional communication standards vary.[47] Server Infrastructure for Smart Meter AMI In Advanced Metering Infrastructure (AMI), the server infrastructure is crucial for managing, storing, and processing the large volumes of data generated by smart meters. This infrastructure ensures seamless communication between smart meters, utility providers, and end-users, supporting real-time monitoring, billing, and grid management. Key Components of AMI Server Infrastructure Data Concentrator A Data Concentrator Unit (DCU) aggregates data from multiple smart meters within a localized area (e.g., a neighborhood or building) before transmitting it to the central server. Data concentrators reduce the communication load on the network and help overcome connectivity challenges by acting as intermediaries between smart meters and the head-end system (HES). They typically support communication protocols like IEC 62056, DLMS/COSEM[48] Head-End System (HES) The HES is responsible for collecting, validating, and managing data received from data concentrators and smart meters. It serves as the central communication hub, facilitating two-way communication between the smart meters and the utility's central servers. The HES supports meter configuration, firmware updates, and real-time data retrieval, ensuring data integrity and security.[49] Meter Data Management System (MDMS) The MDMS is a specialized software platform that stores and processes large volumes of meter data collected by the HES. Key functions of the MDMS include data validation, estimation, and editing, as well as billing preparation, load analysis, and anomaly detection. The MDMS integrates with other utility systems, such as billing, customer relationship management (CRM), and demand response systems, to enable efficient energy management.[50] Data Analytics Data analytics for smart meters leverages machine learning to extract insights from energy consumption data. Key applications include demand forecasting, dynamic pricing, Energy Disaggregation, and fault detection, enabling optimized grid performance and personalized energy management. These techniques drive efficiency, cost savings, and sustainability in modern energy systems. "Energy Disaggregation, or the breakdown of your energy use based on specific appliances or devices",[51] is an exploratory technique for analyzing energy consumption in households, commercial buildings, and industrial settings. By using data from a single energy meter, it employs algorithms and machine learning to estimate individual appliance usage without separate monitors. Known as Non-Intrusive Load Monitoring (NILM), this emerging method offers insights into energy efficiency, helping users optimize usage and reduce costs. While promising, energy disaggregation is still being refined for accuracy and scalability as part of smart energy management innovations.[52] Data management The other critical technology for smart meter systems is the information technology at the utility that integrates the Smart Meter networks with utility applications, such as billing and CIS. This includes the Meter Data Management system. This section may contain material not related to the topic of the article. Please help improve this section or discuss this issue on the talk page. (December 2024) (Learn how and when to remove this message) It also is essential for smart grid implementations that power line communication (PLC) technologies used within the home over a Home Area Network (HAN), are standardized and compatible. The HAN allows HVAC systems and other household appliances to communicate with the smart meter, and from there to the utility. Currently there are several broadband or narrowband standards in place, or being developed, that are not yet compatible. To address this issue, the National Institute for Standards and Technology (NIST) established the PAP15 group, which studies and recommends coexistence mechanisms with a focus on the harmonization of PLC Standards for the HAN. The objective of the group is to ensure that all PLC technologies selected for the HAN coexist as a minimum. The two leading broadband PLC technologies selected are the HomePlug AV / IEEE 1901 and ITU-T G.hn technologies.[53] Technical working groups within these organizations are working to develop appropriate coexistence mechanisms. The HomePlug Powerline Alliance has developed a new standard for smart grid HAN communications called the HomePlug Green PHY specification. It is interoperable and coexistent with the widely deployed HomePlug AV technology and with the latest IEEE 1901 global Standard and is based on Broadband OFDM technology. ITU-T commissioned in 2010 a new project called G.hnem, to address the home networking aspects of energy management, built upon existing Low Frequency Narrowband OFDM technologies. Opposition and concerns Some groups have expressed concerns regarding the cost, health, fire risk,[54] security and privacy effects of smart meters[55] and the remote controllable "kill switch" that is included with most of them. Many of these concerns regard wireless-only smart meters with no home energy monitoring or control or safety features. Metering-only solutions, while popular with utilities because they fit existing business models and have cheap up-front capital costs, often result in such "backlash". Often the entire smart grid and smart building concept is discredited in part by confusion about the difference between home control and home area network technology and AMI. The (now former) attorney general of Connecticut has stated that he does not believe smart meters provide any financial benefit to consumers,[56] however, the cost of the installation of the new system is absorbed by those customers. Security Smart meters expose the power grid to cyberattacks that could lead to power outages, both by cutting off people's electricity[57] and by overloading the grid.[58] However many cyber security experts state that smart meters of UK and Germany have relatively high cybersecurity and that any such attack there would thus require extraordinarily high efforts or financial resources.[59][60][61] The EU Cyber security Act took effect in June 2019, which includes Directive on Security Network and Information Systems establishing notification and security requirements for operators of essential services.[62] Through the Smartgrid Cybersecurity Committee, the U.S. Department of Energy published cybersecurity guidelines for grid operators in 2010 and updated them in 2014. The guidelines "...present an analytical framework that organizations can use to develop effective cybersecurity strategies..."[63] Implementing security protocols that protect these devices from malicious attacks has been problematic, due to their limited computational resources and long operational life.[64] The current version of IEC 62056 includes the possibility to encrypt, authenticate, or sign the meter data. One proposed smart meter data verification method involves analyzing the network traffic in real-time to detect anomalies using an Intrusion Detection System (IDS). By identifying exploits as they are being leveraged by attackers, an IDS mitigates the suppliers' risks of energy theft by consumers and denial-of-service attacks by hackers.[65] Energy utilities must choose between a centralized IDS, embedded IDS, or dedicated IDS depending on the individual needs of the utility. Researchers have found that for a typical advanced metering infrastructure, the centralized IDS architecture is superior in terms of cost efficiency and security gains.[64] In the United Kingdom, the Data Communication Company, which transports the commands from the supplier to the smart meter, performs an additional anomaly check on commands issued (and signed) by the energy supplier. As Smart Meter devices are Intelligent Measurement Devices which periodically record the measured values and send the data encrypted to the Service Provider, therefore in Switzerland these devices need to be evaluated by an evaluation Laboratory, and need to be certified by METAS from 01.01.2020 according to Prüfmethodologie (Test Methodology for Execution of Data Security Evaluation of Swiss Smart Metering Components). According to a report published by Brian Krebs, in 2009 a Puerto Rico electricity supplier asked the FBI to investigate large-scale thefts of electricity related to its smart meters. The FBI found that former employees of the power company and the company that made the meters were being paid by consumers to reprogram the devices to show incorrect results, as well as teaching people how to do it themselves.[66] Several hacking tools that allow security researchers and penetration testers verify the security of electric utility smart meters have been released so far.[67] Health Most health concerns about the meters arise from the pulsed radiofrequency (RF) radiation emitted by wireless smart meters.[68] Members of the California State Assembly asked the California Council on Science and Technology (CCST) to study the issue of potential health impacts from smart meters, in particular whether current FCC standards are protective of public health.[69] The CCST report in April 2011 found no health impacts, based both on lack of scientific evidence of harmful effects from radio frequency (RF) waves and that the RF exposure of people in their homes to smart meters is likely to be minuscule compared to RF exposure to cell phones and microwave ovens.[70] Daniel Hirsch, retired director of the Program on Environmental and Nuclear Policy at UC Santa Cruz, criticized the CCST report on the grounds that it did not consider studies that suggest the potential for non-thermal health effects such as latent cancers from RF exposure. Hirsch also stated that the CCST report failed to correct errors in its comparison to cell phones and microwave ovens and that, when these errors are corrected, smart meters "may produce cumulative whole-body exposures far higher than that of cell phones or microwave ovens."[71] The Federal Communications Commission (FCC) has adopted recommended Permissible Exposure Limit (PEL) for all RF transmitters (including smart meters) operating at frequencies of 300 kHz to 100 GHz. These limits, based on field strength and power density, are below the levels of RF radiation that are hazardous to human health.[72] Other studies substantiate the finding of the California Council on Science and Technology (CCST). In 2011, the Electric Power Research Institute performed a study to gauge human exposure to smart meters as compared to the FCC PEL. The report found that most smart meters only transmit RF signals 1% of the time or less. At this rate, and at a distance of 1 foot from the meter, RF exposure would be at a rate of 0.14% of the FCC PEL.[73] An indirect potential for harm to health by smart meters is that they enable energy companies to disconnect consumers remotely, typically in response to difficulties with payment. This can cause health problems to vulnerable people in financial difficulty; in addition to denial of heat, lighting, and use of appliances, there are people who depend on power to use medical equipment essential for life. While there may be legal protections in place to protect the vulnerable, many people in the UK were disconnected in violation of the rules.[74] Safety Issues surrounding smart meters causing fires have been reported, particularly involving the manufacturer Sensus. In 2012. PECO Energy Company replaced the Sensus meters it had deployed in the Philadelphia, US region after reports that a number of the units had overheated and caused fires. In July 2014, SaskPower, the province-run utility company of the Canadian province of Saskatchewan, halted its roll-out of Sensus meters after similar, isolated incidents were discovered. Shortly afterward, Portland General Electric announced that it would replace 70,000 smart meters that had been deployed in the state of Oregon after similar reports. The company noted that it had been aware of the issues since at least 2013, and they were limited to specific models it had installed between 2010 and 2012.[75] On July 30, 2014, after a total of eight recent fire incidents involving the meters, SaskPower was ordered by the Government of Saskatchewan to immediately end its smart meter program, and remove the 105,000 smart meters it had installed.[76] Privacy concerns One technical reason for privacy concerns is that these meters send detailed information about how much electricity is being used each time. More frequent reports provide more detailed information. Infrequent reports may be of little benefit for the provider, as it doesn't allow as good demand management in the response of changing needs for electricity. On the other hand, widespread reports would allow the utility company to infer behavioral patterns for the occupants of a house, such as when the members of the household are probably asleep or absent.[77] Furthermore, the fine-grained information collected by smart meters raises growing concerns of privacy invasion due to personal behavior exposure (private activity, daily routine, etc.).[20] Current trends are to increase the frequency of reports. A solution that benefits both provider and user privacy would be to adapt the interval dynamically.[78] Another solution involves energy storage installed at the household used to reshape the energy consumption profile.[79][80] In British Columbia the electric utility is government-owned and as such must comply with privacy laws that prevent the sale of data collected by smart meters; many parts of the world are serviced by private companies that are able to sell their data.[81] In Australia debt collectors can make use of the data to know when people are at home.[82] Used as evidence in a court case in Austin, Texas, police agencies secretly collected smart meter power usage data from thousands of residences to determine which used more power than "typical" to identify marijuana growing operations.[83] Smart meter power data usage patterns can reveal much more than how much power is being used. Research has demonstrated that smart meters sampling power levels at two-second intervals can reliably identify when different electrical devices are in use.[84][85][86][87][88][89][90][91] Ross Anderson wrote about privacy concerns "It is not necessary for my meter to tell the power company, let alone the government, how much I used in every half-hour period last month"; that meters can provide "targeting information for burglars"; that detailed energy usage history can help energy companies to sell users exploitative contracts; and that there may be "a temptation for policymakers to use smart metering data to target any needed power cuts."[92] Opt-out options Reviews of smart meter programs, moratoriums, delays, and "opt-out" programs are some responses to the concerns of customers and government officials. In response to residents who did not want a smart meter, in June 2012 a utility in Hawaii changed its smart meter program to "opt out".[93] The utility said that once the smart grid installation project is nearing completion, KIUC may convert the deferral policy to an opt-out policy or program and may charge a fee to those members to cover the costs of servicing the traditional meters. Any fee would require approval from the Hawaii Public Utilities Commission. After receiving numerous complaints about health, hacking, and privacy concerns with the wireless digital devices, the Public Utility Commission of the US state of Maine voted to allow customers to opt-out of the meter change at the cost of $12 a month.[94] In Connecticut, another US state to consider smart metering, regulators declined a request by the state's largest utility, Connecticut Light & Power, to install 1.2 million of the devices, arguing that the potential savings in electric bills do not justify the cost. CL&P already offers its customers time-based rates. The state's Attorney General George Jepsen was quoted as saying the proposal would cause customers to spend upwards of $500 million on meters and get few benefits in return, a claim that Connecticut Light & Power disputed.[95] Abuse of dynamic pricing Smart meters allow dynamic pricing; it has been pointed out that, while this allows prices to be reduced at times of low demand, it can also be used to increase prices at peak times if all consumers have smart meters.[96] Additionally smart meters allow energy suppliers to switch customers to expensive prepay tariffs instantly in case of difficulties paying. In the UK during a period of very high energy prices from 2022, companies were remotely switching smart meters from a credit tariff to an expensive prepay tariff which disconnects supplies unless credit has been purchased. While regulations do not permit this without appropriate precautions to help those in financial difficulties and to protect the vulnerable, the rules were often flouted.[74] (Prepaid tariffs could also be levied without smart meters, but this required a dedicated prepay meter to be installed.) In 2022, 3.2 million people were left without power at some point after running out of prepay credit.[97] Limited benefits There are questions about whether electricity is or should be primarily a "when you need it" service where the inconvenience/cost-benefit ratio of time-shifting of loads is poor. In the Chicago area, Commonwealth Edison ran a test installing smart meters on 8,000 randomly selected households together with variable rates and rebates to encourage cutting back during peak usage.[98] In Crain's Chicago Business article "Smart grid test underwhelms. In the pilot, few power down to save money.", it was reported that fewer than 9% exhibited any amount of peak usage reduction and that the overall amount of reduction was "statistically insignificant".[98] This was from a report by the Electric Power Research Institute, a utility industry think tank who conducted the study and prepared the report. Susan Satter, senior assistant Illinois attorney general for public utilities said "It's devastating to their plan......The report shows zero statistically different result compared to business as usual." [98] By 2016, the 7 million smart meters in Texas had not persuaded many people to check their energy data as the process was too complicated.[99] A report from a parliamentary group in the UK suggests people who have smart meters installed are expected to save an average of £11 annually on their energy bills, much less than originally hoped.[100] The 2016 cost-benefit analysis was updated in 2019 and estimated a similar average saving.[101] The Australian Victorian Auditor-General found in 2015 that 'Victoria's electricity consumers will have paid an estimated $2.239 billion for metering services, including the rollout and connection of smart meters. In contrast, while a few benefits have accrued to consumers, benefits realisation is behind schedule and most benefits are yet to be realised'[102] Erratic demand Smart meters can allow real-time pricing, and in theory this could help smooth power consumption as consumers adjust their demand in response to price changes. However, modelling by researchers at the University of Bremen suggests that in certain circumstances, "power demand fluctuations are not dampened but amplified instead."[103] In the media In 2013, Take Back Your Power, an independent Canadian documentary directed by Josh del Sol was released describing "dirty electricity" and the aforementioned issues with smart meters.[104] The film explores the various contexts of the health, legal, and economic concerns. It features narration from the mayor of Peterborough, Ontario, Daryl Bennett, as well as American researcher De-Kun Li, journalist Blake Levitt,[105] and Dr. Sam Milham. It won a Leo Award for best feature-length documentary and the Annual Humanitarian Award from Indie Fest the following year. UK roll-out criticism In a 2011 submission to the Public Accounts Committee, Ross Anderson wrote that Ofgem was "making all the classic mistakes which have been known for years to lead to public-sector IT project failures" and that the "most critical part of the project—how smart meters will talk to domestic appliances to facilitate demand response—is essentially ignored."[106] Citizens Advice said in August 2018 that 80% of people with smart meters were happy with them. Still, it had 3,000 calls in 2017 about problems. These related to first-generation smart meters losing their functionality, aggressive sales practices, and still having to send smart meter readings.[107] Ross Anderson of the Foundation for Information Policy Research has criticised the UK's program on the grounds that it is unlikely to lower energy consumption, is rushed and expensive, and does not promote metering competition. Anderson writes, "the proposed architecture ensures continued dominance of metering by energy industry incumbents whose financial interests are in selling more energy rather than less," and urged ministers "to kill the project and instead promote competition in domestic energy metering, as the Germans do – and as the UK already has in industrial metering. Every consumer should have the right to appoint the meter operator of their choice."[108] The high number of SMETS1 meters installed has been criticized by Peter Earl, head of energy at the price comparison website comparethemarket.com. He said, "The Government expected there would only be a small number of the first-generation of smart meters before Smets II came in, but the reality is there are now at least five million and perhaps as many as 10 million Smets I meters."[109] UK smart meters in southern England and the Midlands use the mobile phone network to communicate, so they do not work correctly when phone coverage is weak. A solution has been proposed, but was not operational as of March 2017.[109] In March 2018 the National Audit Office (NAO), which watches over public spending, opened an investigation into the smart meter program, which had cost £11bn by then, paid for by electricity users through higher bills.[110][111] The National Audit Office published the findings of its investigation in a report titled "Rolling out smart meters" published in November 2018.[112] The report, amongst other findings, indicated that the number of smart meters installed in the UK would fall materially short of the Department for Business, Energy & Industrial Strategy (BEIS) original ambitions of all UK consumers having a smart meter installed by 2020. In September 2019, smart meter rollout in the UK was delayed for four years.[113] Ross Anderson and Alex Henney wrote that "Ed Miliband cooked the books" to make a case for smart meters appear economically viable. They say that the first three cost-benefit analyses of residential smart meters found that it would cost more than it would save, but "ministers kept on trying until they got a positive result... To achieve 'profitability' the previous government stretched the assumptions shamelessly".[114] A counter-fraud officer at Ofgem with oversight of the roll-out of the smart meter program who raised concerns with his manager about many millions of pounds being misspent was threatened in 2018 with imprisonment under section 105 of the Utilities Act 2000, prohibiting disclosure of some information relevant to the energy sector, with the intention of protecting national security.[115][116] The Employment Appeal Tribunal found that the law was in contravention of the European Convention on Human Rights.[117] Main Suppliers Top ten smart electricity meters suppliers depends on the ranking method[118] Among them Landis+Gyr Itron Xylem (formerly Sensus) Sagemcom [fr] Honeywell / Elster Kamstrup A/S [da] Wasion Holdings Limited [zh] Holley Technology Ltd Gallery Newer retrofitted U.S. domestic digital electricity meter Elster REX[119] with 900 MHz[120] mesh network topology for automatic meter reading and "EnergyAxis" time-of-use metering.[121][122][123] Each local mesh networked smart meter has a hub such as this Elster A3 Type A30, which interfaces 900MHz smart meters to the metering automation server via a landline.[124] Itron OpenWay electricity Smart meter with two-way communications for remote reading in use by DTE Energy om Wikipedia, the free encyclopedia (Redirected from Electric energy) Electrical energy is the energy transferred as electric charges move between points with different electric potential, that is, as they move across a potential difference. As electric potential is lost or gained, work is done changing the energy of some system. The amount of work in joules is given by the product of the charge that has moved, in coulombs, and the potential difference that has been crossed, in volts.[1] Electrical energy is usually sold by the kilowatt hour (1 kW·h = 3.6 MJ) which is the product of the power in kilowatts multiplied by running time in hours. Electric utilities measure energy using an electricity meter, which keeps a running total of the electrical energy delivered to a customer. Electric heating is an example of converting electrical energy into thermal energy. The simplest and most common type of electric heater uses electrical resistance to convert the energy. There are other ways to use electrical energy. Electric charges moves as a current the heater element which has a potential difference between the ends: energy is transferred from the charges to the element, increasing the element's temperature and thermal energy as the charges lose potential energy. Electricity generation Main article: Electricity generation Electricity generation is the process of generating electrical energy from other forms of energy. The fundamental principle of electricity generation was discovered during the 1820s and early 1830s by the British scientist Michael Faraday. His basic method is still used today: electric current is generated by the movement of a loop of wire, or disc of copper between the poles of a magnet.[2] For electrical utilities, it is the first step in the delivery of electricity to consumers. The other processes, electricity transmission, distribution, and electrical energy storage and recovery using pumped-storage methods are normally carried out by the electric power industry.[3] Electricity is most often generated at a power station by electromechanical generators, primarily driven by heat engines fueled by chemical combustion or nuclear fission but also by other means such as the kinetic energy of flowing water and wind. There are M-Bus or Meter-Bus is a European standard (EN 13757-2 physical and link layer, EN 13757-3 application layer) for the remote reading of water, gas or electricity meters. M-Bus is also usable for other types of consumption meters, such as heating systems or water meters. The M-Bus interface is made for communication on two wires, making it cost-effective. A radio variant of M-Bus Wireless M-Bus is also specified in EN 13757–4. The M-Bus was developed to fill the need for a system for the networking and remote reading of utility meters, for example to measure the consumption of gas or water in the home. This bus fulfills the special requirements of remotely powered or battery-driven systems, including consumer utility meters. When interrogated, the meters deliver the data they have collected to a common master, such as a hand-held computer, connected at periodic intervals to read all utility meters of a building. An alternative method of collecting data centrally is to transmit meter readings via a modem. Other applications for the M-Bus such as alarm systems, flexible illumination installations, heating control, etc. are suitable. Relation to the OSI model Since no bus system was available for the requirements of meter reading, the M-Bus was developed by Horst Ziegler of the University of Paderborn in cooperation with Texas Instruments Deutschland GmbH and Techem GmbH [de]. The concept was based on the ISO-OSI Reference Model, in order to realize an open system which could use almost any desired protocol. Since the M-Bus is not a network, and therefore does not - among other things - need a transport or session layer, the levels four to six of the OSI model are empty. Therefore, only the physical, the data link, the network and the application layer are provided with functions. OSI Model Data unit Layer Standard Host layers Data 7. Application EN1434-3 6. Presentation Empty 5. Session Empty Segment/Datagram 4. Transport Empty Media layers Packet 3. Network Optional Frame 2. Data link IEC 60870 Bit 1. Physical M-Bus Physical wire and connectors M-Bus connection is called M-Bus or HAN (Home Area Network) consumer connection. M-Bus uses two-wire telephone cable (JYStY 1x2x0.8 mm or similar, 73 ohm/km, 120 nF/km) maximum length of 350 meters when using nominal transfer speeds 300 and 9600 baud. Lowering the speed up to 1000 meter cable can be used. There is no standardized connector, but RJ11 and RJ12 Modular connectors are used by meter manufacturers.[1] The master communication uses voltage signaling, where 1 (idle state, mark) is the bus nominal 36 volts, 0 (space) drops the voltage to 24 volts. As bus voltage can vary with length and load, the signal is specified as 1 for bus voltage drop less than 5.5V, 0 for drop higher than 8.2 volts. Slaves communicate by current consumption, where 1 (idle state, mark) is less than 1.5 milliamperes, 0 (space) raises current to 11-20 mA. The signal is specified as the at least 11 mA current increase. The slaves are connected via diode bridge and can use either polarity of the wires. To protect the bus against shortcircuited slaves, a 430 ohm is connected in series at each slave (or, two 215 ohm resistors, one for each wire). A M-bus load unit is 1.5 mA. Most slaves use at most this, some can need two units (3 mA). Masters can provide type-dependent number of load units, and usually visually indicate overload. Data link protocol The data link protocol is described by IEC 870-5, or its updated version, IEC 60870-5. The data are sent in serial form, at speed between 300 and 9600 bit/s (some variants may operate up to 19200 or 38400 bit/s), using one start bit, one stop bit, and even parity (8e1). The least significant bit is sent first. When sending packets ("telegrams"), there is no pause between stop and subsequent start bit. Suggested speeds are 300, 2400, 9600, and with newer hardware 38400 bit/s, while 2400 bit/s is most common. Devices with different baudrates can coexist on the same bus. Some devices use autobauding[clarification needed]. There are four kinds of packets: single character - 0xE5 - acknowledgement short frame, 5 bytes - 0x10, C-field, A-field, checksum, 0x16 - sending simple commands control frame, 9 bytes - 0x68, 0x03, 0x03, 0x68, C-field, A-field, CI-field, checksum, 0x16 oThe control frame is a long frame with no payload. long frame, 9+ bytes - 0x68, length, length, 0x68, C-field, A-field, CI-field, [0..252 payload bytes], checksum, 0x16 C-field is the control/function field. The sequence, from bit 7, is: bit 7: 0 bit 6: 1 for master-to-slave, 0 for slave reply bit 5: ofrom

master: FCB, frame count bit - indicates request to repeat message when reply was not received ofrom slave: ACD, access demand - 1 when slave wishes to transmit class-1 data, priority data (class-2 data is ordinary non-priority) - the master then should request the class-1 data transfer bit 4: ofrom master: FCV, frame count valid - when 0, slave should ignore FCB ofrom slave: DFC, data flow control - when 1, slave can not accept further data bit 3,2,1,0: F3,F2,F1,F0, function code - eg. for short frame, 0 is for initialization of slave, xA is for class-1 (priority) data read, xB is for class-2 (normal) read. For long/control frame, x3 is sending data to slave, x8 is data reply from slave. A-field is the address field. It is a 8-bit number: 0x00 - unset address, assigned at manufacture time, some meters fixed at this 0x01..0xFA - slave addresses 0xFB, 0xFC - reserved 0xFD - "broadcast" for secondary addressing, addressing done on network layer instead of on data link layer 0xFE - test broadcast, all slaves reply (collisions will happen, use for testing with a single slave; slave replies with its own address in A-field), also possible to use when there is only one slave on the bus 0xFF - broadcast, no reply from slaves CI-field is the control information field. Defined at application layer.[2] Length field in control/long frame is sent twice. Both bytes have to be equal. Minimum value is 0x03, as C-field, A-field and CI-field are mandatory parts of the payload. Slaves respond only to correctly formed packets that match their address. Any fault is indicated by lack of response. Absence of response is defined as no response for 330 bit periods (35 ms for 9600 bit/s, 1.1 s for 300 bit/s) plus 50 ms.[3] Numerical values are usually sent in BCD format.[4] Electric energy consumption is energy consumption in the form of electrical energy.[2] About a fifth of global energy is consumed as electricity: for residential, industrial, commercial, transportation and other purposes.[2] The global electricity consumption in 2022 was 24,398 terawatt-hour (TWh), almost exactly three times the amount of consumption in 1981 (8,132 TWh).[3][failed verification] China, the United States, and India accounted for more than half of the global share of electricity consumption. Japan and Russia followed with nearly twice the consumption of the remaining industrialized countries.[3] Overview Electric energy is most often measured either in joules (J), or in watt hours (W·h).[4] 1 W·s = 1 J 1 W·h = 3,600 W·s = 3,600 J 1 kWh = 3,600 kWs = 1,000 Wh = 3.6 million W·s = 3.6 million J Electric and electronic devices consume electric energy to generate desired output (light, heat, motion, etc.). During operation, some part of the energy is lost depending on the electrical efficiency.[5] Electricity has been generated in power stations since 1882.[6] The invention of the steam turbine in 1884 to drive the electric generator led to an increase in worldwide electricity consumption.[7] In 2022, the total worldwide electricity production was nearly 29,000 TWh.[8] Total primary energy is converted into numerous forms, including, but not limited to, electricity, heat and motion.[9] Some primary energy is lost during the conversion to electricity, as seen in the United States, where a little more than 60% was lost in 2022.[9] Electricity accounted for more than 20% of worldwide final energy consumption in 2022, with oil being less than 40%, coal being less than 9%, natural gas being less than 15%, biofuels and waste less than 10%, and other sources (such as heat, solar electricity, wind electricity and geothermal) being more than 5%.[10] The total final electricity consumption in 2022 was split unevenly between the following sectors: industry (42.2%), residential (26.8%), commercial and public services (21.1%), transport (1.8%), and other (8.1%; i.e., agriculture and fishing).[10] In 1981, the final electricity consumption continued to decrease in the industrial sector and increase in the residential, commercial and public services sectors.[10] A sensitivity analysis on an adaptive neuro-fuzzy network model for electric demand estimation shows that employment is the most critical factor influencing electrical consumption.[11] The study used six parameters as input data, employment, GDP, dwelling, population, heating degree day and cooling degree day, with electricity demand as output variable.[11] World electricity consumption See also: List of countries by electricity consumption The table lists 45 electricity-consuming countries, which used about 22,000 TWh. These countries comprise about 90% of the final consumption of 190+ countries. The final consumption to generate this electricity is provided for every country. The data is from 2022.[8][12] In 2022, OECD's final electricity consumption was over 10,000 TWh.[3] In that year, the industrial sector consumed about 42.2% of the electricity, with the residential sector consuming nearly 26.8%, the commercial and public services sectors consuming about 21.1%, the transport sector consuming nearly 1.8%, and the other sectors (such as agriculture and fishing) consuming nearly 8.1%.[10] In recent decades, the consumption in the residential and commercial and public services sectors has grown, while the industry consumption has declined.[3] More recently, the transport sector has witnessed an increase in consumption with the growth in the electric vehicle market.[3] Electricity consumption of selected countries (OECD, 2022)[8][12] Rank Country Final consumption (TWh) Population (millions) Per capita consumption (MWh) — WORLD 24,398 7,960 3.07 1 China 7,214 1,443 5 2 United States 4,272 336 12.71 3 India 1,403 1,401 1 4 Japan 1,132 126 8.98 5 Russia 934 146 6.4 6 Canada 595 38.1 15.62 7 South Korea 553 51.2 10.8 8 Brazil 550 215 2.56 9 Germany 539 82.2 6.55 10 France 463 67.7 6.84 11 Saudi Arabia 317 36 8.81 12 United Kingdom 312 68.4 4.56 13 Indonesia 308 276 1.17 14 Italy 300 60 5 15 Mexico 296 127 2.33 16 Iran 280 83.3 3.36 17 Turkey 264 84 3.14 18 Taiwan 257 23.8[13] 10.8 19 Spain 246 46.8 5.26 20 South Africa 233 60 3.88 21 Australia 225 26 8.65 22 Vietnam 220 100 2.2 23 Thailand 203 70 2.9 24 Malaysia 170 33.2 5.12 25 Egypt 168 105 1.6 26 Poland 156 37.5 4.17 27 Ukraine 154 43.2 3.56 28 Sweden 147 10.2 14.4 29 Argentina 138 46 3 30 United Arab Emirates 136 10.2 13.33 31 Norway 128 5.5 23.27 32 Pakistan 124 226 0.55 33 Netherlands 120 17.5 6.86 34 Belgium 98 11.8 8.33 35 Finland 90 5.6 16.03 36 Chile 84 19.2 4.38 37 Kazakhstan 75 18.7 4 38 Austria 73 9.1 8.02 39 Venezuela 72 28.1 2.56 40 Algeria 66 44 1.5 41 Switzerland 62 9.3 6.67 42 Israel 59 9.4 6.27 43 New Zealand 43 5 8.6 44 Denmark 35 5.8 6.02 45 Ireland 28 5.5 5.1 Consumption per capita The final consumption divided by the number of inhabitants provides a country's consumption per capita. In Western Europe, this is between 4 and 8 MWh/year.[8] (1 MWh = 1,000 kWh) In Scandinavia, the United States, Canada, Taiwan, South Korea, Australia, Japan and the United Kingdom, the per capita consumption is higher; however, in developing countries, it is much lower.[8] The world's average was about 3 MWh/year in 2022.[8] Very low consumption levels, such as those in Philippines, not included in the table, indicate that many inhabitants are not connected to the electricity grid, and that is the reason why some of the world's most populous countries, including Nigeria and Bangladesh, do not appear in the table.[12] Electricity generation and GDP The table lists 30 countries, which represent about 76% of the world population, 84% of the world GDP, and 85% of the world electricity generation.[8][12][14][15] Productivity per electricity generation (concept similar to energy intensity) can be measured by dividing GDP over the electricity generated. The data is from 2019.[8][12][14][15] Electricity generation (2019) and GDP (PPP) (2019) Country Population, millions rank* GDP (PPP), billions (USD) rank* GDP (PPP) per capita rank* Electricity generation (GWh/yr) rank* GDP (PPP) /kWh* China 1,407 1 $14,280 2 $10,149 15 7,503,428 1 $1.9 India 1,366 2 $2,871 6 $2,102 26 1,603,675 3 $1.8 USA 328 3 $21,433 1 $65,345 1 4,411,159 2 $4.9 Indonesia 270.6 4 $1,119 16 $4,135 20 278,942 17 $4.0 Brazil 211 6 $1,878 9 $8,900 18 626,328 7 $3.0 Pakistan 216.6 5 $279 26 $1,288 28 138,626 24 $2.0 Bangladesh 163 8 $302 25 $1,853 27 89,672 27 $3.4 Nigeria 201 7 $448 22 $2,229 25 33,552[16] 28 $13.4 Russia 144 9 $1,687 11 $11,715 14 1,118,143 4 $1.5 Japan 126 11 $5,149 3 $40,865 7 1,030,286 5 $5.0 Mexico 127.6 10 $1,269 15 $9,945 16 322,584 13 $3.9 Philippines 108 13 $377 23 $3,491 21 106,041 26 $3.6 Vietnam 96.5 15 $262 27 $2,715 24 227,461 21 $1.2 Ethiopia 112 12 $96 29 $857 29 14,553[17] 29 $6.6 Egypt 100.4 14 $303 24 $3,018 23 200,563 22 $1.5 Germany 83 18 $3,888 4 $46,843 4 609,406 8 $6.4 Turkey 83.5 17 $761 19 $9,114 17 303,898 15 $2.5 DR Congo 86.8 16 $50 30 $576 30 9,990[18] 30 $5.0 Iran 83 19 $258 28 $3,108 22 318,696 14 $0.8 Thailand 69.6 20 $544 21 $7,816 19 186,503 23 $2.9 France 67.3 21 $2,729 7 $40,550 8 562,842 10 $4.8 UK 66.8 22 $2,879 5 $43,099 6 324,761 12 $8.9 Italy 59.7 23 $2,009 8 $33,652 9 293,853 16 $6.8 South Korea 51.7 24 $1,651 12 $31,934 10 585,301 9 $2.8 Spain 47.1 25 $1,393 13 $29,575 11 267,501 19 $5.2 Canada 37.6 26 $1,742 10 $46,330 5 648,676 6 $2.7 Saudi Arabia 34.3 27 $793 18 $23,120 13 343,661 11 $2.3 Taiwan 23.6[13] 28 $605[19] 20 $25,636 12 274,059 18 $2.2 Australia 25.4 29 $1,392 14 $54,803 2 265,901 20 $5.2 Netherlands 17.3 30 $910 17 $52,601 3 121,062 25 $7.5 World 7,683 — $87,555 — $11,395 — 27,044,191 — $3.5 Population data is from the World Bank[12] GDP data is from the World Bank[14] Electricity data is from BP Global[15] rank* of Population, GDP, and Electricity generation are rankings within this list GDP (PPP) / kWh is the amount of GDP (PPP) (USD) produced per kilowatt-hour Electricity consumption by sector The table below lists the 15 countries with the highest final electricity consumption, which comprised more than 70% of the global consumption in 2022.[8] Electricity final consumption by sector (2022) Country/ Geographical region Total (TWh) Industry Transport Commercial /Public services Residential Agriculture /Forestry Other China 7,214 59.9% 2.4% 7.3% 16.4% 2.2% 11.8% United States 4,272 19.9% 0.6% 35.2% 37.4% 2.1% 4.8% India 1,403 37.7% 11.2% 7.8% 21.7% 15.9% 5.7% Japan 1,132 37% 1.8% 33.7% 27.1% 0.3% 0.1% Russia 934 44.8% 11.1% 20.4% 21.1% 2.5% 0.1% Canada 595 35.9% 1.5% 28.1% 32.5% 2.0% 0% South Korea 553 52.3% 0.6% 31.4% 12.7% 2.5% 0.5% Brazil 550 38.3% 0.7% 27.3% 27.7% 6% 0% Germany 539 44.8% 2.3% 26.4% 25.4% 1.1% 0% France 463 26.9% 2.4% 31.5% 37% 1.9% 0.3% Saudi Arabia 317 33.7% 3.9% 28.3% 25% 4.1% 5% United Kingdom 312 18.3% 2.2% 38.2% 39.1% 2% 0.2% Italy 300 30% 5% 32% 30% 1% 2% Mexico 296 29% 4% 33% 30% 3% 1% Iran 280 24% 6% 37% 25% 5% 3% World 24,398 42.2% 1.8% 21.1% 26.8% 3.1% 5% Electricity outlook This section needs to be updated. Please help update this article to reflect recent events or newly available information. (February 2022) Looking forward, increasing energy efficiency will result in less electricity needed for a given demand in power, but demand will increase strongly on the account of:[20] Economic growth in developing countries,[20] and Electrification of transport and heating. Combustion engines are replaced by electric drive and for heating less gas and oil, but more electricity is used, if possible with heat pumps.[20] The International Energy Agency expects revisions of subsidies for fossil fuels which amounted to $550 billion in 2013, more than four times renewable energy subsidies. In this scenario,[21] almost half of the increase in 2040 of electricity consumption is covered by more than 80% growth of renewable energy. Many new nuclear plants will be constructed, mainly to replace old ones. The nuclear part of electricity generation will increase from 11 to 12%. The renewable part goes up much more, from 21 to 33%. The IEA warns that in order to restrict global warming to 2 °C, carbon dioxide emissions[22] must not exceed 1000 gigaton (Gt) from 2014. This limit is reached in 2040 and emissions will not drop to zero ever. The World Energy Council[23] sees world electricity consumption increasing to more than 40,000 TWh/a in 2040. The fossil part of generation depends on energy policy. It can stay around 70% in the so-called "Jazz" scenario where countries rather independently "improvise" but it can also decrease to around 40% in the "Symphony" scenario if countries work "orchestrated" for more climate friendly policy. Carbon dioxide emissions, 32 Gt/a in 2012, will increase to 46 Gt/a in Jazz but decrease to 26 Gt/a in Symphony. Accordingly, until 2040 the renewable part of generation will stay at about 20% in Jazz but increase to about 45% in Symphony. An EU survey conducted on climate and energy consumption in 2022 found that 63% of people in the European Union want energy costs to be dependent on use, with the greatest consumers paying more. This is compared to 83% in China, 63% in the UK and 57% in the US.[24][25] 24% of Americans surveyed believing that people and businesses should do more to cut their own usage (compared to 20% in the UK, 19% in the EU, and 17% in China).[26][27] Nearly half of those polled in the European Union (47%) and the United Kingdom (45%) want their government to focus on the development of renewable energies. This is compared to 37% in both the United States and China when asked to list their priorities on energy.[26][28][29] The United States is on track to break electricity consumption records in 2025 and 2026, according to the U.S. Energy Information Administration's (EIA) Short-Term Energy Outlook, released in February 2025. With demand from data centers powering artificial intelligence and cryptocurrency operations, alongside rising electricity use in homes and businesses for heating and transportation, the EIA projects total power consumption will hit 4,179 billion kilowatt-hours (kWh) in 2025 and 4,239 billion kWh in 2026—both surpassing the current record of 4,082 billion kWh set in 2024. The forecasted increase can be broken down as follows: residential electricity sales will climb to 1,524 billion kWh in 2025, commercial demand to 1,458 billion kWh, and industrial usage to 1,054 billion kWh. This would mark new highs for the commercial sector, which set its current record of 1,421 billion kWh in 2024, and for residential consumers, whose last peak was 1,509 billion kWh in 2022. Meanwhile, the industrial sector—historically the largest consumer of electricity—remains just below its all-time high of 1,064 billion kWh set in 2000. As AI, cryptocurrency mining, and electrification continue to drive demand, the U.S. power grid faces mounting pressure to keep pace with this record surge in electricity consumption.[30] Topic 2 experimental company theory practical 2.1 .Overview : Keyword description Update Regarding Your Application Inbox Eaton TalentHub 11:43 AM (1 hour ago) to me Hi Fiston, Thank you for applying for the position of Area Sales Manager - Industrial Sales – 40445. We appreciate you considering a career at Eaton. After careful review, we have decided to move forward with other candidates who more closely match the current needs for this team and position. We know that messages like this are disappointing, but we really hope you continue to pursue other opportunities at Eaton. Be sure to check out Eaton.com/careers, where you can find all our open jobs and set up a job alert. Thank you for your interest in Eaton and wish you all the best! Eaton Talent Acquisition Team Thank you for choosing Eaton UPS Service Level Agreement Inbox Eaton Unsubscribe 10:49 AM (2 hours ago) to me Thank you for registering View this email online Thank you for interest in Eaton UPS Service Level Agreement Dear Tshingombe tshitadi, Congratulations on taking a step toward peace of mind in the management of your critical power backup solution ! Below is the summary of your requirement, kindly note that this is not an official agreement, if you requested to be contacted by Eaton, our sales team will get in touch to discuss alignment with your maintenance strategy. We are looking forward to speaking with you, UPS Services Team Choose what should be included in your contract: Emergency response (8/5 or 24/7) Yes Would you like to minimise your OPEX expenses by including travel and labour costs in the contract? Yes Would you like to include also all spare parts expenses in the contract? Yes Cyber Secured Monitoring - including 24/7 monitoring, remote diagnostic, periodical health reports Yes USP type: BladeUPS kVA: 36 UPS Serial no: 30 First Name: Tshingombe Email: tshingombefiston@gmail.com Company name: tshingombe Service Plan: PREMIUM Last Name: tshitadi Phone no.: +27072529846 Country : South Africa Connect with Eaton: Eaton is a power management company. We provide energy-efficient, hydraulic, electrical and mechanical power more efficiently, safely and sustainably. This email was sent to tshingombefiston@gmail.com by Eaton. Links in this e-mail are tracked for marketing purposes to ensure we deliver the most relevant content to you. To ensure that you continue to receive important updates and newsletters, please add MarketingAfrica@Eaton.com to your safe-senders list. Eaton Electric (South Africa) Pty Ltd, Private Bag X019, Wadeville, Gauteng, South Africa, 1422 Manage your preferences | Privacy Policy | Unsubscribe from all channels | Email us | www.eaton.com Thank you for contacting EatonCare Inbox Eaton Unsubscribe 10:56 AM (2 hours ago) to me View this email online Thank You Thank You for contacting EatonCare. Our team will address your request shortly. If you have an urgent need, our contact information is: Contact Email Address: EatonCareEMEATraining@eaton.com Contact Phone Number: +31 (0)41 85 70 200 Contact Address: 1123 Budapest, Hungary; Nagyenyed u. 8-14. To learn more about your EatonCare support team: More about EatonCare Meet your support team More about Eaton Connect with Eaton: Eaton is a power management company. We provide energy-efficient, hydraulic, electrical and mechanical power more efficiently, safely and sustainably. This email was sent to tshingombefiston@gmail.com by Eaton. Links in this e-mail are tracked for marketing purposes to ensure we deliver the most relevant content to you. To ensure that you continue to receive important updates and newsletters, please add MarketingAfrica@Eaton.com to your safe-senders list. Eaton Electric (South Africa) Pty Ltd, Private Bag X019, Wadeville, Gauteng, South Africa, 1422 Manage your preferences | Privacy Policy | Unsubscribe from all channels | Email us | www.eaton.com My profile Contact details Top of Form Contact Details Personal Details Given Name: TSHINGOMBE Email Address: TSHINGOMBEFISTON@GMAIL.COM Account type(s): Supplier Company Details Company Name: TSHINGOMBE TSHITADI Country: ZA Address: 103 ROCKVIEW YEHOVILL .JHB, 20 PERCY STREET Zip or Postal Code: 1030 Business Phone: 0725298946 Mobile Phone: 0725298946 Update Contact Details Bottom of Form Current access Top of Form Current Access Application Access: Eaton University Bottom of Form Learning & Development Resources Learning and development resources contains learning activities to help to build your existing knowledge and learn new skills and competencies. HR Capabilities Assessing Potential Coaching Change Management Business Acumen Organizational Assessment & Design (OAD) Workforce Analytics Functional Technical Training Employee & Labor Relations Talent Acquisition Learning Priorities Additional HR Learning HR Deployment Calls Revisit Global HR Orientation HR Professional Bundle DIGITAL LEARNING CENTER Eaton's Digital Foundation Digital transformation is happening at Eaton. Artificial Intelligence Training Digital Transformation Overview Introduction to Functional Productivity Industry 4.0 Digital Mindset Click on the below resources to learn more. Data Analytics Design Thinking Agile Risk Taking Continuous Improvement Digital Technologies Learn more about Eaton University for Enterprise Learn about the biggest digital transformation in learning happening at Eaton. Go through the below webinar recordings to know more: Webinar 1 Webinar 2 Reach out to us via the Employee Center, (select "EU for Enterprise") Join the "Eaton University for Enterprise" yammer channel to get regular updates Plan your Development LeaderX Talent Hub Bootcamp Calendar Sustainability Report Top News Create classes, Record attendance, Access reports with 80% productivity savings using the Eaton University Classes and Registration system (LMS). If you are the EHS Manager, Quality Manager, HR Manager delivering learning at your site, please reach out to Brooke Atkinson (Americas), Victoria Chytaylo (EMEA), Tang Min (APAC) or Geetanjali Malshe (India and South East Asia) to know more. Connect with us on the Eaton University for Enterprise yammer group to learn more and keep up with launch communications. Check out the Eaton University EMEA Program Plan here! What are your learning objectives for this year? Review the Eaton University EMEA 2025 Learning Catalogue for an overview of learning programs by subject, and the Program Schedule for an overview of scheduled instructor led session in the region to find the best learning solution for you! Virtual Classroom Training in My Region Explore the list of Virtual Classroom/Virtual Instructor Led training in your region. You can filter further by time zones within your region. Classroom Training in My Country Explore the list of Classroom Training in your country. You can also filter by location within your country. All Learning Catalog Explore the list courses in Eaton University for you. EMEA Catalogue AMERICAS Catalogue APAC Catalogue EMEA Schedule China Trainer List APAC Schedule Instructions This page has powerful features. Click here to learn the features and how you can use it for your learning needs. Once you open the catalog you can filter the results using the "Options" button on the title menu. You can also, copy-paste the registration link in the browser to register for the course. An active JOE session is essential for the link to be functional. Training Schedule This is a list of current training activities for which you are registered. Search: CURRENT/UPCOMING Expressed Interest Pending signatures Completed Canceled Waiting list or pending approval Learner Attachments CURRENT/UPCOMINGAll CURRENT/UPCOMINGOngoing Activities CURRENT/UPCOMINGUpcoming Activities CURRENT/UPCOMINGFixed Duration Activities CURRENT/UPCOMINGCompletion Requested Activities Displaying 7 of 7 Records Displaying 7 of 7 Records Registered ETN_8DPSO_GBL_SCM_CP In Progress ETN_8DPSO 10/27/2024 In Progress EDUCYMEAFHA Registered ETN_ATLTR Registered ETN_ATLTR_A25 4/28/2025 4/28/2025 In Progress GEIS_CH_HLT_CRHL2 In Progress ETN_PPTM1 In Progress ETN_EL_PPAPO In Progress EDUTLTPDU Training Schedule Generated By: tshingombe tshitadi View: Current activities Created on: Sunday, February 23, 2025 4:33:19 AM EST Activity Name Status Code Region Start Date End Date Course Pointer : 8D Problem Solving Overview Registered ETN_8DPSO_GBL_SCM_CP e-Learning Course : 8D Problem Solving Overview of 8D Problem Solving Overview In progress ETN_8DPSO 10/27/2024 7:28 AM EDT e-Learning Course : Arc Flash Hazards Assessment and Protection Device Coordination Webinar In progress EDUCYMEAFHA 2/22/2025 5:20 AM EST Instructor Led Course : Assessing Talent (LeaderX Talent Review Webinars) Registered ETN_ATLTR Instructor Led Class : Assessing Talent (LeaderX Talent Review Webinars) For EMEA Registered ETN_ATLTR_A25 4/28/2025 4:00 AM EDT 4/28/2025 5:00 AM EDT e-Learning Course : Cabling Requirements in Hazardous Locations - Part II In progress GEIS_CH_HLT_CRHL2 2/22/2025 5:39 AM EST e-Learning Course : Power press Training Module 1 - PPE & Housekeeping Certification In progress ETN_PPTM1 2/22/2025 5:17 AM EST e-Learning Course : Production Part Approval Process - Overview In progress ETN_EL_PPAPO 2/22/2025 6:03 AM EST e-Learning Course : Switched PDUs (Technical Course) In progress EDUTLTPDU 2/22/2025 5:30 AM EST TRAINING TRANSCRIPT FOR TSHINGOMBE TSHITADI List of completed activities from 2/23/2024 to 2/23/2025 Username: tshingombefiston@gmail.com E-mail: TSHINGOMBEFISTON@GMAIL.COM Primary domain: Global SCM Primary organization: Primary job: User number: tshingombefiston@gmail.com ACTIVITIES Activity Signature Status Start Date Completion Date Learner Signature Date Score Attended Duration Completion Status e-Learning Course: Eaton: Supporting Your CDP Disclosure 2/23/2025 2/23/2025 Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 53 Attended e-Learning Course: Eaton's Low-Voltage Switchgear 2/22/2025 2/22/2025 Day(s): 0, Hour(s): 0, Minute(s): 2, Second(s): 26.3 Attended e-Learning Course: Eaton Electrical - SEM + Addendum 2/22/2025 2/22/2025 16.67 Failed Day(s): 0, Hour(s): 0, Minute(s): 2, Second(s): 23 Attended e-Learning Course: Sales Training Exam: Eaton G4 Rack PDUs 2/22/2025 2/22/2025 55.55 Failed Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 59.2 Attended e-Learning Course: Sales Training Exam: How to Sell More Cables and Connectivity 2/22/2025 2/22/2025 80 Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 42.6 Attended e-Learning Course: Surge Solutions 2/22/2025 2/22/2025 25 Failed Day(s): 0, Hour(s): 0, Minute(s): 2, Second(s): 10.3 Attended e-Learning Course: Power press Training Module 1 - PPE & Housekeeping 10/27/2024 2/22/2025 Day(s): 0, Hour(s): 0, Minute(s): 1, Second(s): 14 Attended e-Learning Course: Functional Skills Workshop: Human Resources [eLearning] 2/21/2025 2/21/2025 Day(s): 0, Hour(s): 0, Minute(s): 1, Second(s): 19 Attended e-Learning Course: Power press Training Module 1 - PPE & Housekeeping 10/27/2024 10/27/2024 Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 17 Attended Thank you for your application, Fiston! Review your profile information and skills to increase your chances of getting hired. Profile Review Skill Assessment Fiston Tshingombe tshingombefiston@gmail.com Email https://www.linkedin.com/in/tshingombe _tshitadi-9b6204123 Links Johannesburg, South Africa Location +27723456770 Phone Work Experience1 Engineering Jacobs Engineering Feb 2020 - Present enginerring electrical design analyse investigation component Education1 UNIVERSITÉ De Kinshasa UNIKIN Certificate, Engineering Oct 2020 - Jan 2023 Study Program st peace college 10/2020 - Present, jhb r Courses engineering electrical Awards1 Panel wiring electrical St peace college Mar 2024 Panel wiring award certificate. Outlet socket. db . Patents1 Ccma laboure Mar 2024 Ccma labour Publications1 Education technology Tshingombe Mar 2024 Education technologie trade electrical elementaire fundamental My Applications Applications Saved Jobs Showing 53 Jobs Area Sales Manager - Industrial Sales 40445 Feb 23, 2025 Application Processing Nashville, Tennessee, USA, 37211 Production Technician 38169 Jan 16, 2025 No Longer Under Consideration La Vergne, Tennessee, USA, 37086 Eaton Development Program: Power Systems Automation and Controls Engineer 31008 Jan 10, 2025 Application in Review Moon Township, Pennsylvania, USA, 15108 Statutory and Tax Analyst 36199 Dec 12, 2024 Application in Review Johannesburg, Gauteng, ZAF, 1619 Battery Technical Specialist 36800 Dec 12, 2024 Application in Review Montbonnot Saint Martin, FRA, 38330 EHS Manager - Southeast 36045 Nov 30, 2024 No Longer Under Consideration Arden, North Carolina, USA, 28704 Power Systems Engineering Manager 36590 Nov 30, 2024 No Longer Under Consideration Deerfield Beach, Florida, USA, 33442 ReSurge Program: Business Healthcare Development Analyst 35449 Nov 23, 2024 No Longer Under Consideration Nashville, Tennessee, USA, 37211 Project Manager - Power Systems Controls 35679 Nov 14, 2024 No Longer Under Consideration Littleton, Colorado, USA, 80120 Regional Sales Leader Aftermarket Africa 35244 Nov 13, 2024 Application in Review Johannesburg, Gauteng, ZAF, 1619 Principal Design Engineer, Gas Insulated Switchgear (GIS) 24170 Oct 23, 2024 No Longer Under Consideration Greenwood, South Carolina, USA, 29649 EMEA Research & Development Senior Subject Matter Expert - Medium Voltage standards & applications 32409 Oct 20, 2024 No Longer Under Consideration Hengelo, NLD, 7559 Internship Program: Field Service Engineer 30657 Oct 8, 2024 Processed Moon Township, Pennsylvania, USA, 15108 Senior Project Engineer 33025 Oct 8, 2024 No Longer Under Consideration Nashville, Tennessee, USA, 37211 Service Centre Helpdesk Coordinator 33335 Sep 28, 2024 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Lead Design Engineer 33175 Sep 22, 2024 No Longer Under Consideration Louisville, Kentucky, USA, 40299 Field Services Engineer - UPS 32511 Sep 10, 2024 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Senior Field Service Representative 31161 Sep 5, 2024 No Longer Under Consideration Nashville, Tennessee, USA, 37211 Utility Service Sales Specialist 32009 Sep 5, 2024 No Longer Under Consideration Charlotte, North Carolina, USA, 28269 Senior Field Service Representative 31188 Aug 29, 2024 No Longer Under Consideration Nashville, Tennessee, USA, 37211 Skip to main content Home My Jobs Search Jobs 0 results FT My Applications Applications Saved Jobs Showing 53 Jobs Field Service Engineer 30764 Aug 29, 2024 Job Filled - Other Candidate Selected RIYADH, Riyad, SAU, 12482 Technical Services Engineering MFG Technician 30256 Aug 25, 2024 Job Filled - Other Candidate Selected Arecibo, Puerto Rico, USA, 00612 Commercial Finance Manager 31056 Aug 18, 2024 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Key Account Manager - Data Centre Accounts 31211 Aug 18, 2024 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Engineering Manager - Power Electronics CoE 24619 Jun 25, 2024 No Longer Under Consideration Titchfield, GBR, PO14 4QA Field Service Engineer - UPS 26849 May 29, 2024 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Power Systems Engineering Specialist (Expert) 25412 May 19, 2024 No Longer Under Consideration Milton, Ontario, CAN, L9T 5C3 Manager Engineering Product Design Connected Solutions 25058 May 19, 2024 No Longer Under Consideration Santo Domingo, DOM Field Service Engineer - UPS 26105 May 19, 2024 No Longer Under Consideration Cape Town, ZAF, 7550 Service Centre Helpdesk Coordinator 20686 Mar 6, 2024 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Field Services Engineer - UPS 20228 Mar 2, 2024 No Longer Under Consideration Durban, ZAF, 4017 Field Services Engineer - UPS 19852 Feb 10, 2024 No Longer Under Consideration Cape Town, ZAF, 7550 Quality Auditor, Training program, 3rd Shift 19275 Feb 9, 2024 Processed Rumford, Rhode Island, USA, 02916 Lead Power Systems Engineer 19197 Jan 31, 2024 No Longer Under Consideration El Paso, Texas, USA, 79912 Product Manager - Electrical Working Training & Remote Services 18926 Jan 31, 2024 No Longer Under Consideration Moon Township, Pennsylvania, USA, 15108 Finance Early Talent Leadership Development Program (m/w/d) 18647 Jan 31, 2024 No Longer Under Consideration Bonn, DEU, 53115 Finance Early Talent Leadership Development Program 18817 Jan 31, 2024 No Longer Under Consideration Budapest, HUN, 1123 Site Manager South Africa - Customer Projects 12131 Dec 16, 2023 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Engineering Technician - Mechanical 13241 Dec 11, 2023 No Longer Under Consideration Wilsonville, Oregon, USA, 97070-8247 Lead Engineer Power Conversion 14106 Dec 10, 2023 No Longer Under Consideration Bonn, DEU, 53115 Powered by #WhatsNextForYou Skip to main content Home My Jobs Search Jobs 0 results FT My Applications Applications Saved Jobs Showing 53 Jobs Senior Power Electronics HW Engineer 5488 Dec 10, 2023 No Longer Under Consideration Bonn, DEU, 53115 Mechanical Design Engineer - Electrical Vehicle (m/w/d) 14843 Dec 10, 2023 No Longer Under Consideration Bonn, DEU, 53115 Manager Engineering - Engineering Center (Eplan) ESS EMEA 12431 Dec 10, 2023 No Longer Under Consideration Hengelo, NLD, 7559 Senior Electrical Project Engineer 15841 Dec 5, 2023 Job Filled - Other Candidate Selected Dublin, IRL, 4 Applications Engineer 13964 Dec 5, 2023 No Longer Under Consideration Mascot, New South Wales, AUS, 2020 Project Management Engineer 10396 Dec 5, 2023 No Longer Under Consideration Selangor, MYS, 46050 Service Engineer - Power Quality 4449 Dec 3, 2023 No Longer Under Consideration Warszawa, Mazowieckie, POL, 02555 Internship: Engineering Summer - Lincoln, IL 11161 Dec 3, 2023 No Longer Under Consideration Lincoln, Illinois, USA, 62656 Senior Electrical Engineer 13779 Dec 3, 2023 No Longer Under Consideration Raleigh, North Carolina, USA, 27616 Electrical Tender Engineer 12618 Dec 3, 2023 No Longer Under Consideration New Cairo City, EGY, 11835 Project Management Leader South Africa - Customer Projects 12134 Dec 1, 2023 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Project Manager South Africa - Customer Projects 12130 Dec 1, 2023 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Field Service Engineer - UPS 15094 Dec 1, 2023 No Longer Under Consideration Durban, ZAF, 4017 Training Transcript 4. To change the date range, click on the filter in the top left corner Eaton Employees: 1. Login to Eaton University Classes & Registration System (JOE – My Applications) 2. Go to the Self menu in the top left corner 3. Select Reporting > Training Transcript 4. To change the date range, click on the filter in the top left corner We appreciate your input and look forward to fulfilling your future learning needs. If you have any questions or concerns, please contact us at ESASalesEnablement@eaton.com Completion Status for Eaton Electrical - SEM + Addendum Inbox eatonuniversityalerts@eaton.com Sat, Feb 22, 12:55 PM (21 hours ago) to me Powered by EatonUniversity Completion Status Notification Dear tshingombe tshitadi, Sorry, you have not successfully completed the following activity. Please follow the steps given below to re-attempt the course. 1. Take the e-Learning course again. 2. Pass the assessment to complete the course. Activity Code: ETN_EN_EESA Activity Name: Eaton Electrical - SEM + Addendum Completion Date: 2/22/2025 5:51:34 AM EST Pass Status: No To view your Pass or Fail Status for this attempt, please visit you "My Training Completions". Please follow the instructions provided below. For accessing Training completions and diploma certificates: 1. Login to Eaton University Classes & Registration System (JOE – My Applications) 2. Go to "My Training Completions" from Learning dashboard. 3. You can filter on date range as required 4. Click on the certificate icon against respective training to view the certificate 5. Print or Export to pdf using the buttons. We look forward to serving your future development needs. Important: To help us improve this course, please complete this short survey (optional). Thanks and Regards, EatonUniversity Please do not reply to this system generated email. For any questions or assistance, open a service request with Eaton University. To open a service request, open JOE> click on HR Services Catalog (Employee Center) > Search "Eaton University" and login your request. (ensure to have active JOE and OKTA). Completion notification and survey for Sales Training Exam: How to Sell More Cables and Connectivity Inbox eatonuniversityalerts@eaton.com Sat, Feb 22, 12:40 PM (21 hours ago) to me Dear tshingombe tshitadi, Congratulations on the successful completion of: Activity Name: Sales Training Exam: How to Sell More Cables and Connectivity Completion Date: 2/22/2025 5:38:21 AM EST Important: To help us improve this course, please complete this short survey (optional). We look forward to serving your future development needs. Thank you, Eaton University Completion notification and survey for Sales Training Exam: How to Sell More Cables and Connectivity Inbox eatonuniversityalerts@eaton.com Sat, Feb 22, 12:40 PM (21 hours ago) to me Dear tshingombe tshitadi, Congratulations on the successful completion of: Activity Name: Sales Training Exam: How to Sell More Cables and Connectivity Completion Date: 2/22/2025 5:38:21 AM EST Important: To help us improve this course, please complete this short survey (optional). We look forward to serving your future development needs. Thank you, Eaton University Registration confirmation for Assessing Talent (LeaderX Talent Review Webinars) For EMEA Inbox eatonuniversityalerts@eaton.com Sat, Feb 22, 12:35 PM (21 hours ago) to me Apr28Mon Assessing Talent (LeaderX Talent Review Webinars) For EMEA View on Google Calendar When Mon Apr 28, 2025 10am – 11am (SAST) Where (VILT)/Virtual Instructor Led Training Who eatonuniversityalerts@eaton.com* Agenda Mon Apr 28, 2025 No earlier events 10am Assessing Talent (LeaderX Talent Review Webinars) For EMEA No later events Powered by EatonUniversity Registration Confirmation Notification Dear tshingombe tshitadi, You have been successfully registered for the below activity. Course code- ETN_ATLTR_A25 Course Name - Assessing Talent (LeaderX Talent Review Webinars) For EMEA Start Date: 4/28/2025 10:00:00 AM CEST End Date: 4/28/2025 11:00:00 AM CEST Facility and Location: Location: Virtual Instructor Led Training Facility: (VILT) Completion notification and survey for Surge Solutions Inbox eatonuniversityalerts@eaton.com Sat, Feb 22, 12:30 PM (22 hours ago) to me Dear tshingombe tshitadi, Congratulations on the successful completion of: Activity Name: Surge Solutions Completion Date: 2/22/2025 5:28:37 AM EST Important: To help us improve this course, please complete this short survey (optional). We look forward to serving your future development needs. Thank you, Eaton University Registration confirmation for Arc Flash Hazards Assessment and Protection Device Coordination Webinar Inbox eatonuniversityalerts@eaton.com Sat, Feb 22, 12:25 PM (22 hours ago) to me Powered by EatonUniversity Registration Confirmation Notification Dear tshingombe tshitadi, You have been successfully registered for the below activity. Course code- EDUCYMEAFHA Course Name - Arc Flash Hazards Assessment and Protection Device Coordination Webinar User Notes and login details: Please do not reply to this system generated email. For any questions or assistance, open a service request with Eaton University. To open a service request, open JOE> click on Employee Center > Search "Eaton University" and login your request. (ensure to have active JOE and OKTA). When you have completed this activity, you will receive a completion email that includes a link to complete a survey. We greatly appreciate any feedback you can provide to help us improve the course. Thanks and Regards, EatonUniversity Registration confirmation for Power press Training Module 1 - PPE & Housekeeping Inbox eatonuniversityalerts@eaton.com Sat, Feb 22, 12:20 PM (22 hours ago) to me Powered by EatonUniversity * Registration Confirmation Notification * Dear tshingombe tshitadi, You have been successfully registered for the below activity. Course code- ETN_PPTM1 Course Name - Power press Training Module 1 - PPE & Housekeeping Instructions to access 1. Open or login to JOE Homepage 2. Select "Eaton University Classes & Registration" from the "My Applications" section. 3. Once the Eaton University Classes & Registration homepage opens, scroll down to the "To Do" section to locate the course. 4. Please click on start button to launch the course. Important To ensure successful completion of an eLearning course: •Access Eaton University from an Eaton location, or if you are logging in remotely, use a high-speed internet connection. •Use IE11 in compatibility mode and disable any pop-up blockers. •Carefully follow course exit instructions. User Notes: When you have completed this activity, you will receive a completion email that includes a link to complete a survey. We greatly appreciate any feedback you can provide to help us improve the course. Thanks and Regards, EatonUniversity Please do not reply to this system generated email Registration confirmation for Power press Training Module 1 - PPE & Housekeeping Inbox eatonuniversityalerts@eaton.com Sat, Feb 22, 12:20 PM (22 hours ago) to me Powered by EatonUniversity * Registration Confirmation Notification * Dear tshingombe tshitadi, You have been successfully registered for the below activity. Course code- ETN_PPTM1 Course Name - Power press Training Module 1 - PPE & Housekeeping Instructions to access 1. Open or login to JOE Homepage 2. Select "Eaton University Classes & Registration" from the "My Applications" section. 3. Once the Eaton University Classes & Registration homepage opens, scroll down to the "To Do" section to locate the course. 4. Please click on start button to launch the course. Important To ensure successful completion of an eLearning course: •Access Eaton University from an Eaton location, or if you are logging in remotely, use a high-speed internet connection. •Use IE11 in compatibility mode and disable any pop-up blockers. •Carefully follow course exit instructions. User Notes: When you have completed this activity, you will receive a completion email that includes a link to complete a survey. We greatly appreciate any feedback you can provide to help us improve the course. Completion notification and survey for Functional Skills Workshop: Human Resources [eLearning] Inbox eatonuniversityalerts@eaton.com Fri, Feb 21, 12:35 PM (2 days ago) to me Powered by EatonUniversity Activity Completion Notification Dear tshingombe tshitadi, Congratulations on the successful completion of: Activity Code: ETNFRFSWHR_EL Activity Name: Functional Skills Workshop: Human Resources [eLearning] Completion Date: 2/21/2025 5:30:26 AM EST Important: To help us improve this course, please complete this short survey (optional). Wishing to share the accomplishments with your friends, colleagues, and family? If yes, 1. Click here to download the certificate of completion in PDF format. Note: An active JOE (refresh JOE if it has been open for a while) session must be opened to access the download link. 2. Login to your social media platforms (Viva Engage (Yammer), LinkedIn, Twitter, Instagram, Facebook) 3. Create a post, write your caption, attach the downloaded PDF and add the #EatonUniversity and #Eaton hashtags. This post is voluntary. Here is the suggested text for using as the caption for your post: Employees at @Eaton are encouraged to continuously learn, share and grow in their careers. The #Eaton curated learning and development platform, #EatonUniversity, makes that possible. I recently completed a course in Functional Skills Workshop: Human Resources [eLearning]. I'm grateful for these on-the-job opportunities that advance our knowledge, improve performance and help us grow. #whatmatters #lifeateaton #learninganddevelopment. We look forward to serving your future development needs. Thanks and Regards, EatonUniversity Please do not reply to this system generated email. For any questions or assistance, open a service request with Eaton University. To open a service request, open JOE> click on HR Services Catalog (Employee Center) > Search "Eaton University" and login your request. (ensure to have active JOE and OKTA). Back-up power, UPS, surge & IT power distribution Clutches and brakes Conduit, cable and wire management Cylinders Differentials and traction control Electrical circuit protection Electric vehicles and EV charging Energy storage systems Engine solutions Filtration solutions Fuel systems, emissions and components Golf grips Hose, tubing, fittings & connectors Industrial controls, drives, automation & sensors Lighting & controls Low-voltage power distribution & control systems Medium voltage power distribution & control systems Motors & generators Process safety, automation, test & measurement Pumps Safety, security and emergency communications Server racks, enclosures & airflow management Steering systems Support systems Transmissions Utility & grid solutions Valves Vehicle controls, automation & power management Wiring devices & connectivity Build a data center that fits your business needs Whether your infrastructure is a single network closet or hyperscale, our data center solutions can help you power a more efficient, sustainable and secure data center. Explore the path that best fits your operational needs. Applications Network closet Server room Data center white space Facility infrastructure Data center types Small business Medium to larger enterprise Multi-tenant and colocation Hyperscale Design, build and operate more sustainable data centers Realize your decarbonization goals and increase efficiency with solutions and services that enable you to implement, manage and monitor power systems across your data center operations. Our EnergyAware UPS backup power and Brightlayer Data Centers software suite allow you to integrate renewables and make more effective energy decisions with data. Reduce risk with safety and security built in Keep your data, equipment and people safe with predictive security solutions backed by our industry-leading secure-by-design approach, internationally-recognized cybersecurity standards and compliance best practices. From arc flash protection to UL/IEC cybersecurity accreditation, safety and security is built into the foundation of everything we make. Scale easier and get to market faster Realize the value of your investment sooner with accelerated, data-driven design and project management services, easy implementation, pre-tested solutions and expert support. Lower costs, increase revenue and ensure always-on reliability Reduce total cost of ownership and open new revenue streams with flexible, reliable power solutions that support the bi-directional flow of energy and enable you to sell power back to the grid. All while maintaining constant uptime. Knowledge center Turn information into insights. Access our Knowledge center and explore success stories, white papers and more to take your data center into the future. Success story Building data centers to exceed big expectations } Success story Building data centers to exceed big expectations Data center Visualize our solutions in our 3D environment } Data center Visualize our solutions in our 3D environment An explosion 4x hotter than the sun The mere drop of a tool or accidental contact with electrical systems can set off an arc flash and instantly generate an energy explosion releasing temperatures in excess of 36,000°F. That's four times hotter than the sun. Why arc flashes occur An arc flash is the explosive energy released when an electrical fault, for instance a short circuit, causes an arc. The dangers associated with an arc flash event include heat, flying debris, sound, UV radiation and more. 2 3 5 7 6 4 1 Power intensive environments are especially vulnerable In heavy power, continuous operation industries, arc flash poses a very real threat. Environments operating with 125 kVA or larger transformers call for special safety measures. Protecting personnel and equipment is everyone's responsibility. 8 Employees require education Electrical workers must be trained and should understand the risks of arc flash safety. This includes reading and understanding arc flash labels and wearing the proper personal protective equipment (PPE) to perform energized work. Codes and standards are always changing and it is imperative that your organization be in compliance. Arc flash labels provide advance warning Arc flash labels indicate two key pieces of information: The expected incident energy (measured in calories per cm2)—at a working distance of 18 inches or 24 inches—which drives the proper PPE required for protection. And the distance a worker without PPE must work to avoid a non-curable burn (typically measured in feet). Avoiding electrical disasters Time and distance are the most controllable variables reducing the risk of arc flash issues. Reducing the time that an event persists by tripping a breaker or blowing a fuse significantly reduces the arc flash incident energy. Increasing distance to the arc flash by remote operation, or with closed doors or protective barriers, protects workers in case an event occurs. Better equipment can help Installing the right equipment can help mitigate arc flash hazards. Specially designed low voltage motor control centers (MCCs) and switchgear can reduce the probability of electrical shock and arc flash energy during maintenance. As powerful as an 8-stick dynamite blast A 10,000A arc on a 480-volt circuit can have the explosive force of eight (8) sticks of dynamite. Another example of the energy in an arc flash: copper expands at 67,000 times its volume during an arc flash event—a small, pea-sized piece of copper would expand to fill the volume of a railroad car! 9 10 Good safety optimizes operational efficiency A sound safety policy incorporating arc flash safety solutions will protect your people and equipment, minimizing risk and increasing uptime. Human error is often to blame The most common cause of electrical accidents is human error. And the majority of those mistakes occur during routine maintenance of power system equipment or troubleshooting controls. Follow the Charge » to consider when designing your data center 10 THINGS ABOUT ARC FLASH SAFETYEach year, Eaton is performing discharge tests for over 300 000 batteries in Finland, where the EMEA UPS factory is located, to guarantee the safety and the functionality of the complete battery system. Eaton has a performing battery approval process, that leads to utilizing only the premium batteries on the market. In addition, regular audits are performed in all the facilities of the approved battery suppliers of Eaton Battery replacement service Batteries are the core element of any critical power protection system, hence they are assuring the backup time delivery. Most frequent cause of unplanned outages is premature end of life of few battery blocks. Handling batteries without proper training can lead to disastrous results of full UPS system investment 30-80% + - Continuous quality monitoring Eaton is utilizing millions of batteries per year for UPS applications globally. Battery quality indeed plays the most critical role in battery selection criteria. >300 000 BATTERIES>1 000 000 Batteries utilized globally TESTED FOR EATON 3PH UPS IN EMEA PER YEAR As identical as possible battery performance between each battery blocks in the same string is crucial for the battery lifetime and battery string performance. In the graphs there are real test results from the same discharge test for 20 blocks of lower quality and 20 blocks of high quality batteries. With lower quality batteries there is much higher dispersion in the graphs than with high quality batteries. Eaton EMEA 3ph UPS service Good quality battery example Low quality battery example End of discharge Time Voltage Time Voltage End of discharge Changes to the products, to the information contained in this document, and to prices are reserved; so are errors and omissions. Only order confirmations and technical documentation by Eaton is binding. Photos and pictures also do not warrant a specific layout or functionality. Their use in whatever form is subject to prior approval by Eaton. The same applies to Trademarks (especially Eaton, Moeller, and Cutler-Hammer). The Terms and Conditions of Eaton apply, as referenced on Eaton Internet pages and Eaton order confirmations. Follow us on social media to get the latest product and support information. Eaton EMEA Headquarters Route de la Longeraie 7 1110 Morges, Switzerland Eaton.com © 2022 Eaton All Rights Reserved Publication No. SA161013EN June 2022 Eaton is a registered trademark. All other trademarks are property of their respective owners. Safety ensured With over 50 years of experience in qualifying batteries for UPS applications, Eaton is replacing more than 200 000 blocks every year in EMEA. Eaton field service engineers and authorized partners are trained to perform the battery replacement according to the required safety procedures. In addition, Eaton's trained personnel is able to set and operate UPS and battery according to the site specific requirements, like environmental temperature and humidity, and Eaton UPS features like ABM, ESS and VMMS. This is crucial for safety and optimal UPS performance. As an active steward of the environment, Eaton guarantees an efficient disposal of the end-of-life batteries. To benefit from battery replacement and other features, Eaton offers Service Level Agreements for maintaining the condition of your UPS to ensure its continuous performance while allowing you to accurately plan your budget. For more information about UPS services please visit https://www.eaton.com/gb/en-gb/services.html >200 000 BLOCKS REPLACED PER YEAR Years of expertise with UPS batteries 50+ >4000 A can be delivered from a battery cabinet ABM A correct set-up of the charging method promotes battery life ...

it-power-distribution/backup-power-ups/eaton-3s-ups/eaton-3s-ups%20-datasheet.pdf Eaton 3S UPS - Datasheet (application/pdf 466KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-3s-ups/eaton-3s-ups%2520-datasheet.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93ps-marine-ups/eaton-93ps-marine-ups-8-40-kw-users-and-installation-guide.pdf Eaton 93PS Marine UPS 8-40 kW User's and installation guide (application/pdf 3MB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93ps-marine-ups/eaton-93ps-marine-ups-8-40-kw-users-and-installation-guide.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/power-distribution-for-it-equipment/eaton-ats-pdu/Eaton%20ATS%2016%20and%20ATS%2030%20-%20Datasheet.pdf Eaton ATS 16 & ATS 30 - Datasheet (application/pdf 445KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/power-distribution-for-it-equipment/eaton-ats-pdu/Eaton%2520ATS%252016%2520and%2520ATS%252030%2520-%2520Datasheet.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93e-ups-emea/eaton-93e-ups-15-80-kva-installation-and-operation-manual-614-01975-00-en.pdf Eaton 93E UPS 15-80 kVA Installation and operation manual (application/pdf 3MB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93e-ups-emea/eaton-93e-ups-15-80-kva-installation-and-operation-manual-614-01975-00-en.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93px-ups/eaton-ups-declaration-origin-en-us.pdf Eaton UPS Declaration of Origin (application/pdf 282KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93px-ups/eaton-ups-declaration-origin-en-us.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/backup-power-solutions/eaton-upsaar/brochure/eaton-energy-aware-brochure-br153151en-en-us.pdf Eaton energy aware brochure br153151en en us (application/pdf 2MB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/backup-power-solutions/eaton-upsaar/brochure/eaton-energy-aware-brochure-br153151en-en-us.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93e-g2-ups/eaton-93e-g2-%2080-200kva-certificate-doc-en.pdf Eaton 93E G2 UPS 100-200 kVA EU Declaration of Conformity (application/pdf 426KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93e-g2-ups/eaton-93e-g2-%252080-200kva-certificate-doc-en.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton_5e_ups/eaton-5e-ups---emea/eaton-5e-gen2-refdata.docx Reference Data (application/docx 208KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton_5e_ups/eaton-5e-ups---emea/eaton-5e-gen2-refdata.docx /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-9px-ups/user-guides/Eaton%209PX%20UPS%20-%206000%203.1-8000%203.1-11000%203.1-EBM%20240V%20-%20Installation%20and%20user%20manual.pdf Eaton 9PX UPS - 6000 3:1/8000 3:1/11000 3:1/EBM 240V - Installation and user manual (application/pdf 9MB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-9px-ups/user-guides/Eaton%25209PX%2520UPS%2520-%25206000%25203.1-8000%25203.1-11000%25203.1-EBM%2520240V%2520-%2520Installation%2520and%2520user%2520manual.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/5P-Gen2-UPS---EMEA/eaton-5p-gen2-ups-emea-resources/eaton-5pgen2-declaration-origin-en-us.pdf Eaton UPS Declaration of Origin (application/pdf 282KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/5P-Gen2-UPS---EMEA/eaton-5p-gen2-ups-emea-resources/eaton-5pgen2-declaration-origin-en-us.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/power-xpert-9395/power-xpert-9395p-ups-500-kva-technical-specification-en.pdf Power Xpert 9395P UPS 500-600 kVA Technical Specification (application/pdf 198KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/power-xpert-9395/power-xpert-9395p-ups-500-kva-technical-specification-en.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/crouse-hinds/instruction-sheets/crouse-hinds-mtl-fs32-xe-operating-instructions.pdf Crouse-Hinds series MTL FS32-XE instruction sheet (application/pdf 363KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/crouse-hinds/instruction-sheets/crouse-hinds-mtl-fs32-xe-operating-instructions.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/5P-Gen2-UPS---EMEA/eaton-5p-gen2-ups-emea-resources/eaton-5pgen2-tower-user-manual-en-us.pdf Eaton 5P Gen2 Tower UPS Advance User Guide (application/pdf 1MB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/5P-Gen2-UPS---EMEA/eaton-5p-gen2-ups-emea-resources/eaton-5pgen2-tower-user-manual-en-us.pdf /content/dam/eaton/support/apac-support-assets/anz/eaton-single-phase-ups-catalogue-fy24-en-gb-anz.pdf Eaton A/NZ Single Phase UPS Catalogue FY2024 (application/pdf 1MB) https://www.eaton.com/content/dam/eaton/support/apac-support-assets/anz/eaton-single-phase-ups-catalogue-fy24-en-gb-anz.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/power-distribution-for-it-equipment/eaton-basic-rack-pdu/ePDU_Brochure_2012_IEC_version_low_pdf.381.pdf ePDU Brochure 2012 IEC version low pdf (application/pdf 724KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/power-distribution-for-it-equipment/eaton-basic-rack-pdu/ePDU_Brochure_2012_IEC_version_low_pdf.381.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/power-distribution-for-it-equipment/eaton-rack-pdu/eaton-rack-pdu-g4-resources---emea/eaton-dpq-rackpdug4-outline-drawing-9001-22351-EVMIF332X-en-us.pdf Eaton Rack PDU G4 EVMIF332X technical drawing (application/pdf 3MB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/power-distribution-for-it-equipment/eaton-rack-pdu/eaton-rack-pdu-g4-resources---emea/eaton-dpq-rackpdug4-outline-drawing-9001-22351-EVMIF332X-en-us.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton_5e_ups/Eaton%205E%20UPS%20-%20Installation%20and%20user%20manual.pdf Eaton 5E UPS - Installation and user manual (application/pdf 634KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton_5e_ups/Eaton%25205E%2520UPS%2520-%2520Installation%2520and%2520user%2520manual.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93pr/india/eaton-93pr-25-200kw-ups-technical-specification.pdf 93PR (60-1200 kW) Installation and Operation Manual (application/pdf 92MB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93pr/india/eaton-93pr-25-200kw-ups-technical-specification.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/crouse-hinds/catalog-pages/crouse-hinds-mtl-rack-pro-catalog-page.pdf Crouse-Hinds series MTL RackPro catalog page (application/pdf 561KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/crouse-hinds/catalog-pages/crouse-hinds-mtl-rack-pro-catalog-page.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93ps-marine-ups/eaton-93ps-marine-ups-8-40kw-declaration-of-conformity.pdf Eaton 93PS Marine UPS 8-40 kW Declaration of conformity (application/pdf 504KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-93ps-marine-ups/eaton-93ps-marine-ups-8-40kw-declaration-of-conformity.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/crouse-hinds/instruction-sheets/crouse-hinds-aegis-din-rail-surge-protection-device-ac-installation-instructions.pdf Eaton AEGIS DIN rail AC instruction sheet (application/pdf 2MB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/crouse-hinds/instruction-sheets/crouse-hinds-aegis-din-rail-surge-protection-device-ac-installation-instructions.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-5sc-ups/eaton-5sc-ups-500-3000va-datasheet.pdf Eaton 5SC UPS - 500/3000VA - Datasheet (application/pdf 1MB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton-5sc-ups/eaton-5sc-ups-500-3000va-datasheet.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/power-distribution-for-it-equipment/eaton-rack-pdu/eaton-rack-pdu-g4-resources---emea/eaton-dpq-rackpdug4-outline-drawing-9001-22349-EVMAF132X-en-us.pdf Eaton Rack PDU G4 EVMAF132X technical drawing (application/pdf 7MB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/power-distribution-for-it-equipment/eaton-rack-pdu/eaton-rack-pdu-g4-resources---emea/eaton-dpq-rackpdug4-outline-drawing-9001-22349-EVMAF132X-en-us.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/power-distribution-for-it-equipment/eaton-rack-pdu/eaton-rack-pdu-g4-resources---emea/eaton-dpq-rackpdug4-outline-drawing-9001-22347-EVBAF316X-en-us.pdf Eaton Rack PDU G4 EVBAF316X technical drawing (application/pdf 8MB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/power-distribution-for-it-equipment/eaton-rack-pdu/eaton-rack-pdu-g4-resources---emea/eaton-dpq-rackpdug4-outline-drawing-9001-22347-EVBAF316X-en-us.pdf /content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton_5e_ups/eaton-5e-ups---emea/eaton-5e-gen2-model-charts.xlsx 5E Gen2 Model Charts (application/xlsx 28KB) https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/eaton_5e_ups/eaton-5e-ups---emea/eaton-5e-gen2-model-charts.xlsx Configure. Review. Complete. Order. Plan your service according to your maintenance needs and budget Basic: professional routine maintenance for your UPS Standard (+): essential services to minimize failure rate and its impact ("+" supported by Cyber Secured Monitoring) Advanced (+): your choice to optimize maintenance investment ("+" supported by Cyber Secured Monitoring) Premium: integral solution to maximize your power security supported by Cyber Secured Monitoring Choose what should be included in your contract: Emergency response (8/5 or 24/7) Yes No Travel and labour costs Yes No All spare parts expenses Yes No Cyber Secured Monitoring - including 24/7 monitoring, remote diagnostic, periodical health reports Yes No UPS type * kVA * UPS Serial no. Flexible energy systems will power the future The transition to a more sustainable, low-carbon future is accelerating. This energy transition is driven by the progressive replacement of carbon-based fuels with renewables, clean air regulation and the direct and indirect electrification of more applications. Today, energy flows through the grid in more directions and through more devices than ever before, and although that decentralisation creates more complexities and challenges, it also creates new potential. Everything as a Grid is our approach to reinventing the way power is distributed, stored and consumed. Our Everything as a Grid approach is shaping a future where homeowners and businesses can reduce the cost and environmental impact of energy. Flexible, intelligent power creates new opportunities for everyone. Energy transition: Everything as a Grid Our Everything as a Grid approach reinvents how power is distributed, stored and consumed worldwide. Because the world's energy needs are shifting, but what matters isn't. Eaton.com/EnergyTransition Watch the full story The transition to renewable power Global renewable adoption is on the rise; electricity demand is expected to reach 38,700 terawatt-hours by 2050 – with renewables providing 50% of that energy.1 The highly distributed nature of renewable energy is upending the traditional power delivery model. Electricity no longer flows in one direction from the utility that generates it to those who consume it. The new energy ecosystem comprises an intricate network of "prosumers" – consumers and businesses who produce their own energy (usually solar), use what's needed and in many cases, are looking to export excess power back to the grid. Furthermore, the electrification of transport, building systems and industrial processes will drive considerable increases in demand for electrical power over the coming decades. Data centers, offices, factories and similar sites can participate in the transition via battery and thermal energy storage systems and grid-interactive uninterruptible power systems. This will give rise to vast bi-directional electricity flows requiring a network with the flexibility to cope with higher volatility and demand. 57 % Increase in global electricity demand by 2050 13X Growth in energy storage installed base by 2030 4X Growth of electricity required for data and computing by 2030 Planning for the shift to more electrical power The electrification of more areas of the economy, including transport, building systems and industry will drive a substantial increase in power demand by 2050. It is technically feasible to meet this extra demand with electricity generated from low or zero carbon sources. However, this will require concerted government support through policy and regulation as well as research and development to reduce the cost of new green energy sources like clean hydrogen. Decarbonisation: cleaner power Businesses and consumers are participating in cleaner power initiatives. Active corporate sourcing of renewable electricity reached 465 terawatt-hours (TWh), with production for self-consumption reaching 165TWh.2 On the consumer side, electric vehicle (EV) charging technology prices continue to fall, while charging point accessibility continues to rise. By facilitating the trading of self-generated clean electricity, we're enabling energy users, both consumers and businesses, to participate in demand response programmes where the utility can turn demand and/or on-site generation up or down in response to signals for real-time grid balancing needs. Democratisation: less reliance on the grid More homes, businesses and communities are becoming self-sufficient power producers that rely less on the utility grid. They generate, store and consume their own energy via renewable solar arrays, wind turbines, microgrids and battery storage. And they create a bi-directional flow that is changing the way power is managed and reducing the impact of sudden outages caused by rolling blackouts, cyberattacks and extreme weather events. These prosumers may also sell excess energy back to the grid and take advantage of demand response programmes to help reduce utility bills. Digitalisation: connectivity behind powerful decisions Digital innovation can be used to make smarter business or personal energy management decisions. It's the transformation of the data from appliances, equipment or processes into actionable insights that help consumers and businesses drive new efficiencies, maximise uptime and manage their energy footprint. Through technologies that support bi-directional power generation, storage and energy management, we're playing a critical role in helping meet demand growth and balance grid volatility. We are reimagining and rebuilding the electrical power value chain. Need help with the shift to more electrical power? Contact us Embracing the new power paradigm Homes, offices, stadiums, factories and data centres can now generate and store more of their own power to optimise energy costs, lower their carbon footprint and in some cases, reduce reliance on the grid. This is Everything as a Grid. Traditional electrical power infrastructures must be upgraded, with software and services optimising every process, to realise new energy benefits. We enable a systems approach to infrastructure integration and the technologies that help transform power generation and distribution for homes, buildings and utilities. Buildings as a grid Unlock the energy transition for your building See how the energy transition can help you seize the opportunity to improve the performance and expand functional use of your building infrastructure. Eaton introduces its Buildings as a Grid approach to energy transition Eaton introduces its Buildings as a Grid approach to help customers accelerate decarbonization, boost resilience, reduce energy costs and create new revenue streams. Responding to the high demand for low carbon Renewable and battery market shares continue to rise and play a larger role in the global power supply, even in the wake of the COVID-19 pandemic. The steady increase of competitiveness in renewables, along with their modularity, rapid scalability and job creation potential, make them highly attractive as countries and communities evaluate economic stimulus options.3 The challenge lies in balancing variable renewable power and storage options against the always-there, always-on power that users demand. By helping utilities, building managers and homeowners adopt renewable power and storage strategies, we're helping to make clean energy available when and where it's needed. Energy storage Capture renewable energy whenever it's available and use it on demand. You'll see immediate gains in flexibility, realize greater independence from the utility grid and avoid dips in grid power supply due to brownouts, cyberattacks and weather-related events. This transformational technology revolutionises power for all, with energy storage available for the home, commercial and industrial buildings and even large-scale implementations for utilities. EnergyAware UPS Our EnergyAware technology helps applications like data centres to support energy providers by balancing sustainable power generation and consumption. The technology optimises power usage during peak demand hours and helps facilities earn additional revenues from currently deployed assets while maintaining complete control of deployed uninterruptible power systems and batteries. Electric vehicles Changing energy demands will affect infrastructure investments – and understanding that impact will be critical in enabling a resilient systems approach that seamlessly and flexibly integrates different assets and EV infrastructure. Power systems, EV management and charging infrastructure providers can then drive a deeper understanding of energy usage to maximise energy efficiency and lower operational costs to consumers. Microgrids Built to help isolate power from the main grid, microgrids balance multiple sources of on-site generation and demand to make energy available when it is needed. Grid modernisation Discover how utilities can adopt grid modernisation technologies to build resilient, efficient and secure power networks. Find out more about Eaton's global sustainability commitments, including carbon neutrality by 2030 Find out more Adapting to fast-changing regulations Regulators are starting to make important changes to incentivise services like demand response to reduce costs, encourage and integrate the uptake of clean energy and increase customer participation. However, we have far to go if we are to replicate best practices and further encourage innovation. This includes financial mechanisms that reward utilities and distribution companies for contracting with distributed energy providers in place of capital investments – a departure from traditional regulation in which the addition of new capital assets is the main source of profit. Through market data analysis and expert insights, we help companies and countries prepare for and embrace the regulatory changes needed to assure a reliable power mix. Ensuring cybersecurity throughout the transition Only 48% of utility executives feel they are prepared to handle the challenges of a cyberattack interruption.4 As utilities address the challenges of improving power reliability and efficiency, they must also contend with the near-constant barrage of security threats. We proactively address cyber threats via a system-wide defensive approach and an unwavering focus on the dangers malware, spyware and ransomware present across the globe. Our team members meet and exceed competencies recognised by international standards organisations like UL, IEC, ISA and others through rigorous, in-depth technical training programmes. Our "secure-by-design" philosophy, processes and secure development lifecycle are integrated into product development and guide our labs, procurement and design teams as the foundation of innovation. And our understanding of and influence in changing global standards help guide safer, more efficient energy infrastructures. Powering the energy transition The technologies that convert wind and sunlight to renewable energy have matured, allowing for more flexible power possibilities. The growth of renewables, localised electricity generation and bi-directional energy helps more homes, businesses and communities produce their own clean, dependable energy for less reliance on the utility grid. Count on Eaton for the technologies and digital intelligence needed for you to join this energy transition. Through our Everything as a Grid approach, infrastructures can be re-managed to ensure optimal efficiency, so you can realise more efficient, sustainable power that costs less. MTL4500/MTL5500 range Analogue Input Modules with passive input for 4-wire separately powered transmitters MTL4541A, MTL4541AS, MTL5541A, MTL5541AS, MTL4544A, MTL4544AS, MTL5544A, MTL5544AS April 2024 SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 Safety manual MTL intrinsic safety solutions FUNCTIONAL SAFETY MANAGEMENT These products are for use as elements within a Safety System conforming to the requirements of IEC 61508:2010 and enable a Safety Integrity Level of up to SIL 2 as described in the functional safety manual. Eaton Electric Ltd, Luton is a certified Functional Safety Management company meeting the requirements of IEC61508:2010 Part 1, Clause 6. * * Subject to special conditions for detection of out-of-range signal currents. Refer to content of this manual for details. SIL IEC 61508:2010 2 SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 This manual supports the application of the products in functional-safety related loops. It must be used in conjunction with other supporting documents to achieve correct installation, commissioning and operation. Specifically, the data sheet, instruction manual and applicable certificates for the particular product should be consulted, all of which are available on the MTL web site. In the interest of further technical developments, Eaton reserve the right to make design changes. Contents 1 Introduction 3 1.1 Application and function 3 1.2 Variant description 3 1.3 Product build revisions covered by this manual 4 2 System configuration 5 2.1 Associated system components 6 3 Selection of product and implications 6 4 Assessment of functional safety 6 4.1 Hardware Safety Integrity 6 4.2 Systematic Safety Integrity 7 4.3 SIL Capability 7 4.4 Example of use in a safety function 7 4.5 EMC 8 4.6 Environmental 8 5 Installation 8 6 Maintenance 9 7 Appendices 9 7.1 Appendix A: Summary of applicable standards 9 7.2 Appendix B: Proof Test Procedure, MTLx541A/AS, MTLx544A/AS Modules 10 - 12 Analogue Input Modules with passive input for 4-wire transmitters Hardware Fault Tolerance (HFT) † Module type 0, 1 MTL4541A, MTL4541AS, MTL5541A, MTL5541AS, MTL4544A, MTL4544AS, MTL5544A, MTL5544AS † These modules have an inherent fault tolerance of 0. SIL IEC 61508:2010 2 SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 1 INTRODUCTION 1.1 Application and function The Analogue Input module types MTLx541A/MTLx541AS (single channel) and MTLx544A/MTLx544AS (dual channel) are intrinsic safety isolators that interface with process measurement transmitters located in a hazardous area of a process plant. They are also designed and assessed according to IEC 61508 for use in safety instrumented systems up to SIL 2. The MTLx541A provides an input for a separately-powered 4/20mA transmitter located in a hazardous area, and repeats the transmitter current into a load in the safe area. The MTLx544A supports two identical channels for use with two separate transmitters. The MTLx541AS and MTLx544AS versions act as a current sink for the safe area connection rather than driving the current into the load. All the modules allow bi–directional transmission of HART communication signals superimposed on the 4/20mA loop current, so that the transmitter can be interrogated either from the operator station or by a hand- held communicator (HHC). There are no configuration switches or operator controls to be set on the modules. These modules are members of the MTL4500 and MTL5500 range of products. 1.2 Variant Description Functionally the MTL4500 and MTL5500 range of modules are the same but differ in the following way: - the MTL4500 modules are designed for backplane mounted applications - the MTL5500 modules are designed for DIN-rail mounting. In both models the hazardous area field-wiring connections (terminals 1,2, and optionally 4,5) are made through the removable blue connectors, but the safe area and power connections for the MTL4544A/MTL4544AS modules are made through the connector on the base, while the MTL5544A/MTL5544AS modules use the removable grey connectors on the top and side of the module. Note that the safe-area connection terminal numbers differ between the backplane and the DIN-rail mounting models. The analogue input models covered by this manual are: Module type Number of channels Safe area connection MTL4541A and 5541A 1 Current source MTL4541AS and 5541AS 1 Current sink MTL4544A and 5544A 2 Current source MTL4544AS and 5544AS 2 Current sink Note: To avoid repetition, further use of MTLx54xA and MTLx54xAS in this document can be understood to include both DIN-rail and backplane models. Individual model numbers will be used only where there is a need to distinguish between them. All the module types described in this manual have the same capacity for the field signals, supporting 4-wire process transmitters or currents sourced in the hazardous area. The connection of the repeated current signals into the input measurement channels for the safety logic system follows the arrangement shown in the following diagram. When the input channels of the Safety Instrumented System (SIS) are providing power for the loop, the 'S' variants of the isolator modules are used to 'sink' the measuring current. In the other cases the isolator modules 'source' the measuring current that flows into a load resistor inside the input card of the Safety Instrumented System. 4SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 2+ 1- Pwr 0V 24V Safety Instrumented System (SIS) Logic Solver with 'Passive' input MTLx541A/ MTLx544A (Safe area current source) B A 2+ 1- Pwr 0V 24V Safety Instrumented System (SIS) Logic Solver with 2-wire input A B Current limiter Output terminal MTL4541A, MTL4541AS MTL5541A, MTL5541AS A 8 11 B 9 12 4-wire Transmitter or current source Pwr Field wiring MTLx541AS/MTLx544AS (Safe area current sink) Figure 1.1 – Input and output connections 1.3 Product build revisions covered by this manual The information provided in this manual is valid for the product build revisions listed in the following table: Model Type Product build revision covered by this manual MTL4541A Up to and including 08 MTL4541AS Up to and including 08 MTL5541A Up to and including 08 MTL5541AS Up to and including 08 MTL4544A Up to and including 08 MTL4544AS Up to and including 08 MTL5544A Up to and including 08 MTL5544AS Up to and including 08 The product build revision is identified by the field 'CC' in the module Product Identification Number that appears at the bottom left-hand corner of the side label: The CC field immediately precedes the 7-digit Serial Number field, DDDDDDD. Example: 5SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 2 System configuration An MTLx54x module may be used in single-channel (1oo1) safety functions up to SIL 2. The worked example in this manual is for a SIL 2 application. The figure below shows the system configuration and specifies detailed interfaces to the safety-related and non safety-related system components. It does not aim to show all details of the internal module structure, but is intended to support understanding for the application. The MTLx54xA/MTLx54xAS modules are designed to receive an active 4-20mA signal from separately powered process transmitters in the hazardous area and to repeat the current flowing in the field loop to the safe-area load. The shaded area indicates the safety-related system connection, while the power supply con- nections are not safety-related. The term 'Logic Solver' has been used to denote the safety system performing the monitoring function of the process loop variable. Note: When using the MTLx544A/MTLx544AS dual-channel modules, it is not appropriate for both channels to be used in the same loop, or the same safety function, as this creates concerns regarding common-cause failures. Consideration must also be given to the effect of common-cause failures when both loops of a dual- channel module are used for different safety functions. Hazardous area Safe area Logic Solver (Safety related) Logic Solver (Safety related) Power supply (Not safety related) MTL5544A/MTL5544AS (2-channel version) shown. MTL5541A/MTL5541AS (single-channel version) omits Ch 2. 20 - 35V dc 6SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 2.1 Associated System Components There are many parallels between the loop components that must be assessed for intrinsic safety as well as functional safety. In both situations the contribution of each part is considered in relation to the whole. The MTLx54xA/MTLx54xAS modules are components in the signal path between safety-related process trans- mitters and safety-related control systems. The transmitter or other field device must be suitable for the process and have been assessed and independently verified for use in functional safety applications. The field instrument and Analogue input card of the Logic Solver shall have a normal operating range of 4-20mA but be capable of working over an extended range of 3 to 22mA for under- and over-range. The Logic Solver shall have the ability to detect and annunciate input currents higher than the threshold of 21mA and lower than the threshold of 3.6mA to determine out-of-range conditions. Note that the transmission of HART data is not considered as part of the safety function and is excluded from this analysis. However, for HART data communication to take place, the input impedance of the receiving equip- ment must be at least 240R. 3 Selection of product and implications The safe area output signal from the MTLx541A/MTLx544A modules is within the operating range of 4-20mA under normal conditions. If the field wiring to the transmitter or connection between the isolator and logic solver is open-circuit then the loop current will fall to less than 3.6mA and close to zero. If the field wiring connection between the transmitter and isolator is short-circuited, the loop current will also fall to below 3.6mA. For module types MTLx541A and MTLx544A that source the 4-20mA signal in the safe area circuit, then the current seen by the logic solver will fall to less than 3.6mA and close to zero if the connection between the isolator and logic solver is shorted. For module types MTLx541AS and MTLx544AS that sink the 4-20mA signal in the safe area circuit, then the current seen by the logic solver will rise to a value greater than 21mA if the connection between the isolator and logic solver is shorted. In both cases, the fault condition must be detected by the logic solver in Functional Safety applications. This should also include the detection of power supply failures which cause the output of the isolator to fall to zero mA. 4 Assessment of Functional Safety 4.1 Hardware Safety Integrity The hardware assessment shows that MTLx541A/MTLx541AS and MTLx544A/MTLx544AS modules: • have a hardware fault tolerance (HFT) of 0 • are classified as Type A devices ("non-complex" component with well-defined failure modes) • have no internal diagnostic elements The failure rates of these modules at an ambient temperature of 45°C are as follows: Failure mode Failure rate (FIT)* MTL4541A MTL4541AS MTL5541A MTL5541AS MTL4544A MTL4544AS MTL5544A MTL5544AS Output current >21mA (upscale) 3 3 3 14 Output current 2% in error 42 42 49 49 Output current within ±2% 73 73 80 81 *(FITs means failures per 109 hours or failures per thousand million hours) • Reliability data for this analysis is taken from IEC TR 62380:2004 Reliability Data Handbook. • Failure mode distributions are taken principally from IEC 62061:2005 Safety of Machinery. • Stated failure rates for dual-channel modules apply to a single channel. It is assumed that the module is powered from a nominal 24V dc supply and operating at a maximum ambient temperature of 45°C. 7SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 4.2 Systematic Safety Integrity The MTLx54x modules have a systematic safety integrity measure of SC 2. This has been established using compliance Route 1S, as described in IEC 61508-2: 2010, section 7.4.2.2 c. 4.3 SIL Capability Considering both the hardware safety integrity and the systematic capability, this allows the modules to be used in safety functions up to SIL 2 in a simplex architecture (HFT=0), provided SFF ≥60% is the case for the application. The hardware safety integrity assessment has been conducted according to compliance Route 1H, as described in IEC 61508-2:2010, section 7.4.4. (See example below). Note: • Independent of hardware architecture and systematic capability considerations, the hardware probability of failure for the entire safety function needs to be calculated for the application to ensure the required PFH (for a high or continuous demand safety function) or PFDAVG (for a low demand safety function) for the SIL is met. 4.4 Example of use in a safety function In this example, the application context is assumed to be: • the safety function is to repeat current within ±2% • the logic solver will diagnose currents above 21mA and below 3.6mA as faults and take appropriate action The failure modes shown above can then be defined as: Failure mode Category Output current >21mA (upscale) Dangerous detected, dd Output current 2% in error Dangerous undetected, du Output current correct within ±2% No effect, ne* The failure rates of the MTL4541A and MTL5541A for these categories are then (FITs): Model sd su dd du ne* MTL4541A or MTL5541A 0 0 227 42 73 In this example, the safe failure fraction (SFF) is 84.4%. * ne is not used in the calculation of SFF. Defining the "output current correct within ±2%" failure mode as ne represents a conservative approach to the calculation of SFF. Interpreting this failure mode as su (safe, undetected) may also be considered and yields an SFF value of 87.7%. Accordingly, the SFF of all module types described in this manual, when used in the same application, are as follows: Model sd su dd du ne SFF MTL4541A, MTL5541A, MTL4541AS, MTL5541AS 0 0 227 42 73 84.4% MTL4544A, MTL5544A 0 0 267 49 80 84.5% MTL4544AS, MTL5544AS 0 0 267 49 81 84.5% 8SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 4.5 EMC The MTL4500 and MTL5500 modules are designed for operation in normal industrial electromagnetic environ- ment but, to support good practice, modules should be mounted without being subjected to undue conducted or radiated interference, see Appendix A for applicable standards and levels. 4.6 Environmental The MTL4500 and MTL5500 modules operate over the temperature range from -20°C to +60°C, and at up to 95% non-condensing relative humidity. The modules are intended to be mounted in a normal industrial environment without excessive vibration, as specified for the MTL4500 & MTL5500 product ranges. See Appendix A for applicable standards and levels. Continued reliable operation will be assured if the exposure to temperature and vibration are within the values given in the specification. 5 Installation There are two particular aspects of safety that must be considered when installing the MTL4000 or MTL5000 modules and these are: • Functional safety • Intrinsic safety Reference must be made to the relevant sections within the instruction manual for MTL4500 range (INM4500) or MTL5500 range (INM5500) which contain basic guides for the installation of the interface equipment to meet the requirements of intrinsic safety. In many countries there are specific codes of practice, together with industry guidelines, which must also be adhered to. Provided that these installation requirements are followed then there are no additional factors to meet the needs of applying the products for functional safety use. To guard against the effects of dust and water the modules should be mounted in an enclosure providing at least IP54 protection degree, or the location of mounting should provide equivalent protection such as inside an equipment cabinet. In applications using MTL4500 range, where the environment has a high humidity, the mounting backplanes should be specified to include conformal coating. 9SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 6 Maintenance To follow the guidelines pertaining to operation and maintenance of intrinsically safe equipment in a hazardous area, yearly periodic audits of the installation are required by the various codes of practice. In addition, proof- testing of the loop operation to conform with functional safety requirements should be carried out at the intervals determined by safety case assessment. Proof testing must be carried out according to the application requirements, but it is recommended that this be carried out at least once every three years. Refer to Appendix B for the proof testing procedure of the MTLx541A/AS and MTLx544A/AS modules. Note that there may also be specific requirements laid down in the E/E/PE operational maintenance procedure for the complete installation. If an MTLx541A/AS and MTLx544A/AS module is found to be faulty during commissioning or during the normal lifetime of the product, then such failures should be reported to the local MTL office. When appropriate, a Cus- tomer Incident Report (CIR) will be notified by Eaton to enable the return of the unit to the factory for analysis. If the unit is within the warranty period then a replacement unit will be sent. Consideration should be given to the service lifetime for a device of this type, which is in the region of ten years. Operating an MTLx541A/AS and MTLx544A/AS module for longer than this period could invalidate the functional safety analysis, meaning that the overall safety function no longer meets its target SIL. If high failure rates of the MTL modules are detected, indicating that they have entered the 'end of life phase' of their service life, then they should be replaced promptly. 7 Appendices 7.1 Appendix A: Summary of applicable standards This annex lists all standards referred to in the previous sections of this document: IEC 61508:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems. Parts 1 and 2 as relevant EN 61131-2:2003 Programmable controllers – Part 2: Equipment requirement and tests (EMC requirements) EN 61326-1:2013 Electrical equipment for measurement, control and laboratory use – EMC requirements. (Criterion A) IEC 61326-3-1:2017 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for equipment performing or intended to perform safety related functions (functional safety) – General industrial applications. (Criterion FS) NE21:2007 Electromagnetic Compatibility of Industrial Process and Laboratory Control Equipment. (Criterion A) Lloyds Register Type Approval System: 2015, Test Specification Number 1. Specifically vibration: 1.0mm displacement @ 5 to 13.2Hz and EN 60068-2-27 Environmental testing. Test Ea and guidance. Shock. (Criterion FS) 10SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 7.2 Appendix B: Proof Test Procedure, MTLx541A/AS, MTLx544A/AS Modules Confirmation, through testing, that a safety function will operate as designed, is a necessary periodic activity to ensure that the probability of failure upon demand (PFDavg) is maintained. In some applications, the user may prefer to conduct a proof test on the overall safety instrumented function without dismantling or disconnecting the individual instrumentation components, in order to avoid disturbing the integrity of the installation. However, where it is deemed desirable to perform proof testing on the MTL modules individually, the following procedure may be used. Proof tests of the other components of the loop must then be conducted in accordance with their manufacturers' instructions, to maintain the integrity of the overall safety function. Alternative proof tests may be devised and applied, provided they give a similar level of test coverage that is appropriate to the safety function. The tests described here - see Figure 7.1 - compare the output current of the MTL isolator with the input current (A1) over the required range of operation, and measure the "error current" i.e. the difference between the two - as indicated on A2. The tests should be employed per channel, as appropriate. Figure 7.1 - Basic test arrangement Ammeter A2 must be capable of measuring currents of either polarity. If it is not an auto-ranging instrument, set it to a high range before switch on, and then adjust sensitivity to obtain the required reading. Proof Test Procedure Test sequence: 1. System - Normal operation test 2. Input /Output characteristic functional safety test 3. System - Normal operation test Modules types MTL4541A, MTL4544A, MTL5541A, MTL5544A Modules types MTL4541AS, MTL4544AS, MTL5541AS, MTL5544AS 11SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 1 System - Normal operation test Make sure that the module to be tested is operating normally in the target system, without errors and in an energised mode. If the module is in a faulty or de-energised loop, restore normal fault-free and energised operation before testing. 2 Input/Output characteristic functional safety test Observe normal anti-static precautions when handling equipment during device testing. Remove the unit from the target system and connect it as shown in Figure 7.2. This figure shows the arrangement for the MTLx541A/ AS single-channel modules; for equivalent connections for the MTLx544A/AS dual-channel modules, refer to the relevant product data sheets. Note that it is acceptable to leave the unit in the target system but only after ensuring that the all the hazardous area input and safe area output terminals have been disconnected from the system and are available for test. Alternatively, for the backplane-mounted MTL4500 range modules, a separate backplane can be used to provide access to the power and output connections. Note that the combination of the 24V power supply and variable resistor RV1 in the hazardous area connection can be provided by a suitable industrial current simulator, which is likely to be more readily available. Also, the 250R resistor does not need to be a precision type; any value in the range 200-300R is acceptable would suffice, such as a standard value of 240R. Where a second power supply is introduced for testing the MTLx541AS or MTLx544AS module variants, note that both power supplies must be floating and not share a common 0V connection. During testing, a 24V nominal system power supply in the range 20.0 to 35.0V should be connected between terminals 13 and 14 (+ve to terminal 14). Figure 7.2 - Connections for testing the MTLx541A/AS and MTLx544A/AS modules 1 2 3 4 5 6 Ch1 i/p Ch2 i/p Ch2 o/p Ch1 o/p MTL541A 13(–) 14(+) 7 8 9 10 11 12 V VS Power supply + MTL5501-SR 13(-) 14(+) V S + – + – + – + – V + Ch1 i/p Ch2 i/p Insert 250R and 24V supply for MTL54xS modules, otherwise use direct link to o/p(+) 14 13 12 11 10 9 8 7 MTL4541A 1 2 3 4 5 6 Ch1 i/p Ch2 i/p Ch2 o/p Ch1 o/p + – + – + – + – A 1 A1 250RRV 1 + 250R 24V dc 24V dc – – + – + – 12SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 Channel 1 Channel 2 Measurements Make the following measurements. It is recommended to record the results in a table such as that shown on the next page. 1. Adjust resistor RV1 to vary the loop current (measured by Ammeter A1) through the range 4 to 20mA. (Tests 1 - 5 in table) 2. The measured current imbalance (measured by Ammeter A2) over this range should not exceed ±50µA. 3. Adjust RV1 to vary the current (A1) to 3.5mA and then 21.5mA (tests 6 & 7 in table). 4. The measured current imbalance (A2) at these currents should not exceed ±200µA. 5. Record the supply voltage Vs. If appropriate, repeat these measurements for Channel 2. 3 System - Normal operation test Disconnect the test setup from the unit and reconnect the original system configuration. Make sure that the tested unit operates normally in the target system, as before, without errors and in energised mode. Date: ____/____/____ Supply voltage Vs: ____________ V dc Module type: ____________ Serial No: ____________ Test # Description Actual Target 1 Current imbalance (A2) at loop current (A1) = 4mA <±50µA 2 Current imbalance (A2) at loop current (A1) = 8mA <±50µA 3 Current imbalance (A2) at loop current (A1) = 12mA <±50µA 4 Current imbalance (A2) at loop current (A1) = 16mA <±50µA 5 Current imbalance (A2) at loop current (A1) = 20mA <±50µA 6 Current imbalance (A2) at loop current (A1) = 3.5mA <±200µA 7 Current imbalance (A2) at loop current (A1) = 21.5mA <±200µA Test Step# Description Actual Target 1 Current imbalance (A2) at loop current (A1) = 4mA <±50µA 2 Current imbalance (A2) at loop current (A1) = 8mA <±50µA 3 Current imbalance (A2) at loop current (A1) = 12mA <±50µA 4 Current imbalance (A2) at loop current (A1) = 16mA <±50µA 5 Current imbalance (A2) at loop current (A1) = 20mA <±50µA 6 Current imbalance (A2) at loop current (A1) = 3.5mA <±200µA 7 Current imbalance (A2) at loop current (A1) = 21.5mA <±200µA (upscale) 3 3 3 14 Output current 2% in error 42 42 49 49 Output current within ±2% 73 73 80 81 *(FITs means failures per 109 hours or failures per thousand million hours) • Reliability data for this analysis is taken from IEC TR 62380:2004 Reliability Data Handbook. • Failure mode distributions are taken principally from IEC 62061:2005 Safety of Machinery. • Stated failure rates for dual-channel modules apply to a single channel. It is assumed that the module is powered from a nominal 24V dc supply and operating at a maximum ambient temperature of 45°C. SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 4.2 Systematic Safety Integrity The MTLx54x modules have a systematic safety integrity measure of SC 2. This has been established using compliance Route 1S, as described in IEC 61508-2: 2010, section 7.4.2.2 c. 4.3 SIL Capability Considering both the hardware safety integrity and the systematic capability, this allows the modules to be used in safety functions up to SIL 2 in a simplex architecture (HFT=0), provided SFF ≥60% is the case for the application. The hardware safety integrity assessment has been conducted according to compliance Route 1H, as described in IEC 61508-2:2010, section 7.4.4. (See example below). Note: • Independent of hardware architecture and systematic capability considerations, the hardware probability of failure for the entire safety function needs to be calculated for the application to ensure the required PFH (for a high or continuous demand safety function) or PFDAVG (for a low demand safety function) for the SIL is met. 4.4 Example of use in a safety function In this example, the application context is assumed to be: • the safety function is to repeat current within ±2% • the logic solver will diagnose currents above 21mA and below 3.6mA as faults and take appropriate action The failure modes shown above can then be defined as: Failure mode Category Output current >21mA (upscale) Dangerous detected, dd Output current 2% in error Dangerous undetected, du Output current correct within ±2% No effect, ne* The failure rates of the MTL4541A and MTL5541A for these categories are then (FITs): Model sd su dd du ne* MTL4541A or MTL5541A 0 0 227 42 73 In this example, the safe failure fraction (SFF) is 84.4%. * ne is not used in the calculation of SFF. Defining the "output current correct within ±2%" failure mode as ne represents a conservative approach to the calculation of SFF. Interpreting this failure mode as su (safe, undetected) may also be considered and yields an SFF value of 87.7%. Accordingly, the SFF of all module types described in this manual, when used in the same application, are as follows: Model sd su dd du ne SFF MTL4541A, MTL5541A, MTL4541AS, MTL5541AS 0 0 227 42 73 84.4% MTL4544A, MTL5544A 0 0 267 49 80 84.5% MTL4544AS, MTL5544AS 0 0 267 49 81 84.5% 8SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 4.5 EMC The MTL4500 and MTL5500 modules are designed for operation in normal industrial electromagnetic environ- ment but, to support good practice, modules should be mounted without being subjected to undue conducted or radiated interference, see Appendix A for applicable standards and levels. 4.6 Environmental The MTL4500 and MTL5500 modules operate over the temperature range from -20°C to +60°C, and at up to 95% non-condensing relative humidity. The modules are intended to be mounted in a normal industrial environment without excessive vibration, as specified for the MTL4500 & MTL5500 product ranges. See Appendix A for applicable standards and levels. Continued reliable operation will be assured if the exposure to temperature and vibration are within the values given in the specification. 5 Installation There are two particular aspects of safety that must be considered when installing the MTL4500 or MTL5500 modules and these are: • Functional safety • Intrinsic safety Reference must be made to the relevant sections within the instruction manual for MTL4500 range (INM4500) or MTL5500 range (INM5500) which contain basic guides for the installation of the interface equipment to meet the requirements of intrinsic safety. In many countries there are specific codes of practice, together with industry guidelines, which must also be adhered to. Provided that these installation requirements are followed then there are no additional factors to meet the needs of applying the products for functional safety use. To guard against the effects of dust and water the modules should be mounted in an enclosure providing at least IP54 protection degree, or the location of mounting should provide equivalent protection such as inside an equipment cabinet. In applications using MTL4500 range, where the environment has a high humidity, the mounting backplanes should be specified to include conformal coating. 9SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 6 Maintenance To follow the guidelines pertaining to operation and maintenance of intrinsically safe equipment in a hazardous area, yearly periodic audits of the installation are required by the various codes of practice. In addition, proof- testing of the loop operation to conform with functional safety requirements should be carried out at the intervals determined by safety case assessment. Proof testing must be carried out according to the application requirements, but it is recommended that this be carried out at least once every three years. Refer to Appendix B for the proof testing procedure of the MTLx541A/AS and MTLx544A/AS modules. Note that there may also be specific requirements laid down in the E/E/PE operational maintenance procedure for the complete installation. If an MTLx541A/AS and MTLx544A/AS module is found to be faulty during commissioning or during the normal lifetime of the product, then such failures should be reported to the local MTL office. When appropriate, a Cus- tomer Incident Report (CIR) will be notified by Eaton to enable the return of the unit to the factory for analysis. If the unit is within the warranty period then a replacement unit will be sent. Consideration should be given to the service lifetime for a device of this type, which is in the region of ten years. Operating an MTLx541A/AS and MTLx544A/AS module for longer than this period could invalidate the functional safety analysis, meaning that the overall safety function no longer meets its target SIL. If high failure rates of the MTL modules are detected, indicating that they have entered the 'end of life phase' of their service life, then they should be replaced promptly. 7 Appendices 7.1 Appendix A: Summary of applicable standards This annex lists all standards referred to in the previous sections of this document: IEC 61508:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems. Parts 1 and 2 as relevant EN 61131-2:2003 Programmable controllers – Part 2: Equipment requirement and tests (EMC requirements) EN 61326-1:2013 Electrical equipment for measurement, control and laboratory use – EMC requirements. (Criterion A) IEC 61326-3-1:2017 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for equipment performing or intended to perform safety related functions (functional safety) – General industrial applications. (Criterion FS) NE21:2007 Electromagnetic Compatibility of Industrial Process and Laboratory Control Equipment. (Criterion A) Lloyds Register Type Approval System: 2015, Test Specification Number 1. Specifically vibration: 1.0mm displacement @ 5 to 13.2Hz and EN 60068-2-27 Environmental testing. Test Ea and guidance. Shock. (Criterion FS) SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 7.2 Appendix B: Proof Test Procedure, MTLx541A/AS, MTLx544A/AS Modules Confirmation, through testing, that a safety function will operate as designed, is a necessary periodic activity to ensure that the probability of failure upon demand (PFDavg) is maintained. In some applications, the user may prefer to conduct a proof test on the overall safety instrumented function without dismantling or disconnecting the individual instrumentation components, in order to avoid disturbing the integrity of the installation. However, where it is deemed desirable to perform proof testing on the MTL modules individually, the following procedure may be used. Proof tests of the other components of the loop must then be conducted in accordance with their manufacturers' instructions, to maintain the integrity of the overall safety function. Alternative proof tests may be devised and applied, provided they give a similar level of test coverage that is appropriate to the safety function. The tests described here - see Figure 7.1 - compare the output current of the MTL isolator with the input current (A1) over the required range of operation, and measure the "error current" i.e. the difference between the two - as indicated on A2. The tests should be employed per channel, as appropriate. Figure 7.1 - Basic test arrangement Ammeter A2 must be capable of measuring currents of either polarity. If it is not an auto-ranging instrument, set it to a high range before switch on, and then adjust sensitivity to obtain the required reading. Proof Test Procedure Test sequence: 1. System - Normal operation test 2. Input /Output characteristic functional safety test 3. System - Normal operation test Modules types MTL4541A, MTL4544A, MTL5541A, MTL5544A Modules types MTL4541AS, MTL4544AS, MTL5541AS, MTL5544AS SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 1 System - Normal operation test Make sure that the module to be tested is operating normally in the target system, without errors and in an energised mode. If the module is in a faulty or de-energised loop, restore normal fault-free and energised operation before testing. 2 Input/Output characteristic functional safety test Observe normal anti-static precautions when handling equipment during device testing. Remove the unit from the target system and connect it as shown in Figure 7.2. This figure shows the arrangement for the MTLx541A/ AS single-channel modules; for equivalent connections for the MTLx544A/AS dual-channel modules, refer to the relevant product data sheets. Note that it is acceptable to leave the unit in the target system but only after ensuring that the all the hazardous area input and safe area output terminals have been disconnected from the system and are available for test. Alternatively, for the backplane-mounted MTL4500 range modules, a separate backplane can be used to provide access to the power and output connections. Note that the combination of the 24V power supply and variable resistor RV1 in the hazardous area connection can be provided by a suitable industrial current simulator, which is likely to be more readily available. Also, the 250R resistor does not need to be a precision type; any value in the range 200-300R is acceptable would suffice, such as a standard value of 240R. Where a second power supply is introduced for testing the MTLx541AS or MTLx544AS module variants, note that both power supplies must be floating and not share a common 0V connection. During testing, a 24V nominal system power supply in the range 20.0 to 35.0V should be connected between terminals 13 and 14 (+ve to terminal 14). Figure 7.2 - Connections for testing the MTLx541A/AS and MTLx544A/AS modules 1 2 3 4 5 6 Ch1 i/p Ch2 i/p Ch2 o/p Ch1 o/p MTL541A 13(–) 14(+) 7 8 9 10 11 12 V VS Power supply + MTL5501-SR 13(-) 14(+) V S + – + – + – + – V + Ch1 i/p Ch2 i/p Insert 250R and 24V supply for MTL54xS modules, otherwise use direct link to o/p(+) 14 13 12 11 10 9 8 7 MTL4541A 1 2 3 4 5 6 Ch1 i/p Ch2 i/p Ch2 o/p Ch1 o/p + – + – + – + – A 1 A1 250RRV 1 + 250R 24V dc 24V dc – – + – + – 12SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 Channel 1 Channel 2 Measurements Make the following measurements. It is recommended to record the results in a table such as that shown on the next page. 1. Adjust resistor RV1 to vary the loop current (measured by Ammeter A1) through the range 4 to 20mA. (Tests 1 - 5 in table) 2. The measured current imbalance (measured by Ammeter A2) over this range should not exceed ±50µA. 3. Adjust RV1 to vary the current (A1) to 3.5mA and then 21.5mA (tests 6 & 7 in table). 4. The measured current imbalance (A2) at these currents should not exceed ±200µA. 5. Record the supply voltage Vs. If appropriate, repeat these measurements for Channel 2. 3 System - Normal operation test Disconnect the test setup from the unit and reconnect the original system configuration. Make sure that the tested unit operates normally in the target system, as before, without errors and in energised mode. Date: ____/____/____ Supply voltage Vs: ____________ V dc Module type: ____________ Serial No: ____________ Test # Description Actual Target 1 Current imbalance (A2) at loop current (A1) = 4mA <±50µA 2 Current imbalance (A2) at loop current (A1) = 8mA <±50µA 3 Current imbalance (A2) at loop current (A1) = 12mA <±50µA 4 Current imbalance (A2) at loop current (A1) = 16mA <±50µA 5 Current imbalance (A2) at loop current (A1) = 20mA <±50µA 6 Current imbalance (A2) at loop current (A1) = 3.5mA <±200µA 7 Current imbalance (A2) at loop current (A1) = 21.5mA <±200µA Test Step# Description Actual Target 1 Current imbalance (A2) at loop current (A1) = 4mA <±50µA 2 Current imbalance (A2) at loop current (A1) = 8mA <±50µA 3 Current imbalance (A2) at loop current (A1) = 12mA <±50µA 4 Current imbalance (A2) at loop current (A1) = 16mA <±50µA 5 Current imbalance (A2) at loop current (A1) = 20mA <±50µA 6 Current imbalance (A2) at loop current (A1) = 3.5mA <±200µA 7 Current imbalance (A2) at loop current (A1) = 21.5mA 17V @ 20mA) is at least 1.5V greater than the total voltage developed across the transmitter and associated field wiring at 20mA. The Analogue Input module must not itself be part of a Safety Instrumented Function. Its non-hazardous 4-20mA output signal may be part of the basic process control system, but must not be used as part of the Safety Instrumented System. Note that HART communications are not supported on the 4-20mA signal. Note: • The MTL5314 is capable of operating in conjunction with MTL Analogue Input modules (such as MTL5541) that provide power for the hazardous area current loop, where the MTL5314 is connected in series with the process transmitter. This configuration also provides a means of transferring the loop current to the non-hazardous area in addition to the trip alarms, and is shown in other MTL documentation such as the MTL5314 product data sheet. However, this configuration is different to that described in 2.1 above, and has not been assessed for Functional Safety applications. SM5314 rev 1 rev 2 DRAFT - 2401207 4 ASSESSMENT OF FUNCTIONAL SAFETY 4.1 Hardware Safety Integrity The hardware safety integrity stated in this manual is drawn from a Failure Modes, Effects and Diagnostic Analysis (FMEDA) for the MTL5314 Trip Amplifier, conducted on behalf of Eaton-MTL by Exida (Exida report no. MTL 05/05-26 R007, version V1, revision R1). Minor amendments have been made in this manual where appropriate, to ensure that the calculation of Safe Failure Fraction (SFF) is in compliance with IEC 61508-2: 2010. The hardware assessment shows that MTL5314 module: • has a hardware fault tolerance (HFT) of 0 • is classified as a Type A device ("non-complex" component with well-defined failure modes) • has no internal diagnostic elements The failure rates derived by the FMEDA for the MTL5314 are stated as FITs (failures per 109 hours, or failures per thousand million hours) in the table below: Model sd su dd du ne* SFF MTL5314, Low Trip 0 156 0 50 165 75.7% MTL5314, High Trip 0 151 0 56 165 72.9% The Safe Failure Fraction (SFF) shown in the table is calculated as (dd + sd + su) / (du + dd + sd + su), and stated as a percentage. For both trip modes, the calculated SFF is between 60 and 90%, and therefore meets the requirements for SIL 2 according to Table 2 of IEC 61508-2: 2010, for a hardware fault tolerance of 0. * Note that "No-effect" failures (ne) are not used in the calculation of SFF. No-effect failures are defined in IEC 61508-4: 2010 as failures of elements (or components) that are part of the safety function but have no effect on the safety function. 4.2 Assumptions The following assumptions have been made during this analysis: • The fail safe state is defined as the alarm relay in

the MTL5314 being de-energised. • Only one trip output is used in the Safety Instrumented Function. • A single failure will fail the entire product. • Failure rates are constant; wear-out mechanisms are not considered. • Propagation of failures is not relevant. • All components that are not part of the safety function and cannot influence the safety function are excluded. • The stress levels are typical for an industrial environment and can be compared to the Ground Fixed classification of MIL-HDBK-217F. This is similar to Class C (sheltered location) as defined in IEC 60654-1, with temperature and humidity levels within those stated in the product data sheet and Section 4.6 of this manual, and an average long-term temperature of 40oC. • The module is powered from a nominal 24V dc supply. • Power supply failure rates are not considered. SM45314 rev 1 DRAFT - 2401208 4.3 Systematic Safety Integrity The MTL5314 module has a systematic safety integrity measure of SC 2. This has been established using compliance Route 1S, as described in IEC 61508-2: 2010, section 7.4.2.2 c. 4.4 SIL Capability Considering both the hardware safety integrity and the systematic capability, this allows the module to be used in safety functions up to SIL 2 in a simplex architecture (HFT=0). The hardware safety integrity assessment has been conducted according to compliance Route 1H, as described in IEC 61508-2: 2010, section 7.4.4. Note: • Independent of hardware architecture and systematic capability considerations, the hardware probability of failure for the entire safety function needs to be calculated for the application to ensure the required PFH (for a high or continuous demand safety function) or PFDavg (for a low demand safety function) for the SIL is met. 4.5 EMC The MTL5314 module is designed for operation in normal industrial electromagnetic environment but, to support good practice, the module should be mounted without being subjected to undue conducted or radiated interference. See Appendix A for applicable standards and levels. 4.6 Environmental The MTL5314 module is designed for operation over the temperature range from -20°C to +60°C, and at up to 95% non-condensing relative humidity. The module is intended to be mounted in a normal industrial environment without excessive vibration, as specified for the MTL5500 product range. See Appendix A for applicable standards and levels. Continued reliable operation will be assured if the exposure to temperature and vibration are within the values given in the specification. 5 INSTALLATION There are two aspects of safety that must be considered when installing the MTL5314 module. These are: • Functional safety • Intrinsic safety To comply with intrinsic safety requirements, reference should be made to the relevant sections in the instruction manual INM5500, which is available to download from the Eaton-MTL website. In many countries there are also specific codes of practice and industry guidelines, which must also be adhered to. Provided that these installation requirements are followed then there are no additional environmental factors to meet the needs of applying the products for functional safety use. To guard against the effects of dust and water the modules should be mounted in an enclosure providing at least IP54 protection degree, or the mounting location should provide equivalent protection such as inside an equipment cabinet. SM5314 rev 1 rev 2 DRAFT - 2401209 6 MAINTENANCE To follow the guidelines relating to operation and maintenance of intrinsically safe equipment in a hazardous area, yearly periodic audits of the installation are required by the various codes of practice. In addition, proof- testing of the loop operation to conform with functional safety requirements should be carried out at the intervals determined by safety case assessment. Proof testing must be carried out according to the application requirements, but it is recommended that this be performed at least once every three years. Refer to Appendix B for the proof testing procedure for the MTL5314 module. Note that there may also be specific requirements laid down in the E/E/PE operational maintenance procedure for the complete installation. If an MTL5314 module is found to be faulty during commissioning or during the normal lifetime of the product, then such failures should be reported to the local Eaton-MTL office. Where appropriate, a Customer Incident Report (CIR) will be notified by Eaton to enable the unit to be returned to the factory for analysis. If the unit is within the warranty period and the failure is due to defective components or manufacture, then a replacement unit will be sent. Consideration should be given to the service lifetime for a device of this type, which is in the region of ten years. Operating an MTL5314 module for longer than this period could invalidate the functional safety analysis, meaning that the overall safety function no longer meets its target SIL. If high failure rates of the module are detected in service, indicating that they have entered the ‘end of life phase’ of their service life, then they should be replaced promptly. SM45314 rev 1 DRAFT - 24012010 7 APPENDICES 7.1 Appendix A: Summary of applicable standards This annex lists all standards referred to in the previous sections of this document: IEC 61508: 2010 Functional safety of electrical/electronic/programmable electronic safety-related systems. Parts 1 and 2 as relevant EN 61131-2: 2003 Programmable controllers – Part 2: Equipment requirement and tests (EMC requirements) EN 61326-1: 2013 Electrical equipment for measurement, control and laboratory use – EMC requirements. (Criterion A) IEC 61326-3-1: 2017 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for equipment performing or intended to perform safety related functions (functional safety) – General industrial applications. (Criterion FS) NE21:2007 Electromagnetic Compatibility of Industrial Process and Laboratory Control Equipment. (Criterion A) Lloyds Register Type Approval System: 2002, Test Specification Number 1. (specifically vibration: 1.0mm displacement @ 5 to 13.2Hz and 0.7G acceleration @13.2Hz to 100Hz per IEC60068-2-6, test Fc) EN 60068-2-27 Environmental testing. Test Ea and guidance. Shock. (Criterion FS) Note that other standards are referenced in Exida report no. MTL 05/05-26 R007, version V1, revision R1, which was used for the derivation of failure rates used in this manual. SM5314 rev 1 rev 2 DRAFT - 24012011 7.2 Appendix B : Proof Test Procedure, MTL5314 Module Confirmation, through testing, that a safety function will operate as designed, is a necessary periodic activity to ensure that the probability of failure upon demand (PFDavg) is maintained. In some applications, the user may prefer to conduct a proof test on the overall safety instrumented function without dismantling or disconnecting the individual instrumentation components, in order to avoid disturbing the integrity of the installation. However, where it is deemed desirable to perform proof testing on the MTL modules individually, the following procedure may be used. Proof tests of the other components of the loop must then be conducted in accordance with their manufacturers’ instructions, to maintain the integrity of the overall safety function. Alternative proof tests may be devised and applied, provided they give a similar level of test coverage that is appropriate to the safety function. Observe normal anti-static precautions when handling equipment during device testing. Remove the MTL5314 from the target system and observe the following test sequence: 1. Select a variable current source or sink, according to which is most representative of the actual field device in the Safety Instrumented Function. A current sink is representative of typical 2 or 3-wire field transmitters, whereas a current source is representative of the 4-20mA output from 4-wire transmitters. The current source or sink should have a traceable calibration history. 2. Set the current source or sink to 12.0mA, and connect it to the appropriate input terminals on the MTL5314 module as shown in Figure 7.2. 3. Adjust the trip potentiometers on the top of the MTL5314 module for Alarms A and B in turn, until the associated LEDs just extinguish. 4. Set the current source or sink to 11.5mA 5. Using the switches on top of the module, set both Alarms to ‘Low Alarm’. 6. Confirm that the LEDs and alarm relays comply with the status shown in ‘Low Alarm’ column of the table below. A multi-meter set to a low ohms range can be used to check that the relays are open or closed. 7. Set both Alarms to ‘High Alarm’, and confirm that the LEDs and alarm relays comply with the status shown in the ‘High Alarm’ column of the table. 8. Set the current source or sink to 12.5mA and repeat steps 5 to 7. Current High Alarm Low Alarm LEDs Alarm A LEDs Alarm A Terminals 11 - 12 Terminals 10 - 11 Terminals 11 - 12 Terminals 10 - 11 Alarm B Alarm B Terminals 8 - 9 Terminals 7 - 8 Terminals 8 - 9 Terminals 7 - 8 11.5mA on closed open off open closed 12.5mA off open closed on closed open continued SM45314 rev 1 DRAFT - 24012012 Figure 7.2 - Connections for testing MTL5314 module Source or sink 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Trip B Trip A Vs Vs 20 to 35V dc SM5314 rev 1 rev 2 DRAFT - 24012013 THIS PAGE IS LEFT INTENTIONALLY BLANK SM45314 rev 1 DRAFT - 24012014 THIS PAGE IS LEFT INTENTIONALLY BLANK SM5314 rev 1 rev 2 DRAFT - 24012015 THIS PAGE IS LEFT INTENTIONALLY BLANK DRAFT - 20 November 2014 EUROPE (EMEA): +44 (0)1582 723633 mtlenquiry@eaton.com THE AMERICAS: +1 800 835 7075 mtl-us-info@eaton.com ASIA-PACIFIC: +65 6 645 9888 sales.mtlsing@eaton.com The given data is only intended as a product description and should not be regarded as a legal warranty of properties or guarantee. In the interest of further technical developments, we reserve the right to make design changes. Eaton Electric Limited, Great Marlings, Butterfield, Luton Beds, LU2 8DL, UK. Tel: + 44 (0)1582 723633 Fax: + 44 (0)1582 422283 E-mail: mtlenquiry@eaton.com www.mtl-inst.com © 2020 Eaton All Rights Reserved Publication No. SM5314 rev 1 240120 January 2020 DRAFT - 240120 The safety you rely on. See the complete MTL product portfolio at www.mtl-inst.com For more information: If further assistance is required, please contact an authorised MTL Distributor, Sales Office, or Customer Service Department Connect with Eaton, MTL: AUSTRALIA Eaton Electrical (Australia) Pty Ltd, 10 Kent Road, Mascot, New South Wales, 2020, Australia Tel: +61 1300 308 374 Fax: +61 1300 308 463 E-mail: mtlsalesanz@eaton.com BeNeLux MTL Instruments BV Ambacht 6, 5301 KW Zaltbommel The Netherlands Tel: +31 (0)418 570290 Fax: +31 (0)418 541044 E-mail: mtl.benelux@eaton.com CHINA Cooper Electric (Shanghai) Co. Ltd 955 Shengli Road, Heqing Industrial Park Pudong New Area, Shanghai 201201 Tel: +86 21 2899 3817 Fax: +86 21 2899 3992 E-mail: mtl-cn@eaton.com FRANCE MTL Instruments sarl, 7 rue des Rosiéristes, 69410 Champagne au Mont d’Or France Tel: +33 (0)4 37 46 16 53 Fax: +33 (0)4 37 46 17 20 E-mail: mtlfrance@eaton.com GERMANY MTL Instruments GmbH, Heinrich-Hertz-Str. 12, 50170 Kerpen, Germany Tel: +49 (0)22 73 98 12 - 0 Fax: +49 (0)22 73 98 12 - 2 00 E-mail: csckerpen@eaton.com INDIA MTL India, No.36, Nehru Street, Off Old Mahabalipuram Road Sholinganallur, Chennai - 600 119, India Tel: +91 (0) 44 24501660 /24501857 Fax: +91 (0) 44 24501463 E-mail: mtlindiasales@eaton.com ITALY MTL Italia srl, Via San Bovio, 3, 20090 Segrate, Milano, Italy Tel: +39 02 959501 Fax: +39 02 95950759 E-mail: chmninfo@eaton.com JAPAN Cooper Crouse-Hinds Japan KK, MT Building 3F, 2-7-5 Shiba Daimon, Minato-ku, Tokyo, Japan 105-0012 Tel: +81 (0)3 6430 3128 Fax: +81 (0)3 6430 3129 E-mail: mtl-jp@eaton.com NORWAY Norex AS Fekjan 7c, Postboks 147, N-1378 Nesbru, Norway Tel: +47 66 77 43 80 Fax: +47 66 84 55 33 E-mail: info@norex.no RUSSIA Cooper Industries Russia LLC Elektrozavodskaya Str 33 Building 4 Moscow 107076, Russia Tel: +7 (495) 981 3770 Fax: +7 (495) 981 3771 E-mail: mtlrussia@eaton.com SINGAPORE Eaton Electric (Singapore) Pte Ltd 100G Pasir Panjang Road Interlocal Centre #07-08 Singapore 118523 #02-09 to #02-12 (Warehouse and Workshop) Tel: +65 6 645 9888 ext 9864/9865 Fax: +65 6 645 9811 E-mail: sales.mtlsing@eaton.com SOUTH KOREA Cooper Crouse-Hinds Korea 7F. Parkland Building 237-11 Nonhyun-dong Gangnam-gu, Seoul 135-546, South Korea. Tel: +82 6380 4805 Fax: +82 6380 4839 E-mail: mtl-korea@eaton.com UNITED ARAB EMIRATES Cooper Industries/Eaton Corporation Office 205/206, 2nd Floor SJ Towers, off. Old Airport Road, Abu Dhabi, United Arab Emirates Tel: +971 2 44 66 840 Fax: +971 2 44 66 841 E-mail: mtlgulf@eaton.com UNITED KINGDOM Eaton Electric Ltd, Great Marlings, Butterfield, Luton Beds LU2 8DL Tel: +44 (0)1582 723633 Fax: +44 (0)1582 422283 E-mail: mtlenquiry@eaton.com AMERICAS Cooper Crouse-Hinds MTL Inc. 3413 N. Sam Houston Parkway W. Suite 200, Houston TX 77086, USA Tel: +1 281-571-8065 Fax: +1 281-571-8069 E-mail: mtl-us-info@eaton.com www.eaton.eu Application Note 11/2017 AP040017EN PowerXL™ DE1 Variable Speed Starters Motor Data – Motor Protection – V/f curves – Slip Compensation Level 2 1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 2 Contents Disclaimer

2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 3 Danger! - Dangerous electrical voltage! · Disconnect the power supply of the device. · Ensure that devices cannot be accidentally restarted. · Verify isolation from the supply. · Cover or enclose any adjacent live components. · Follow the engineering instructions (AWA/IL) for the device concerned. · Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system. · Before installation and before touching the device ensure that you are free of electrostatic charge. · The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection. · Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automatic control functions. · Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states. · Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specification, otherwise this may cause malfunction and/or dangerous operation. · Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes. Unlatch- ing of the emergency-stop devices must not cause a restart. · Devices that are designed for mounting in housings or control cabinets must only be operated and con- trolled after they have been properly installed and with the housing closed. · Wherever faults may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, me- chanical interlocks etc.). · Variable speed starters may have hot surfaces during and immediately after operation. · Removal of the required covers, improper installation or incorrect operation of motor or variable speed starter may destroy the device and may lead to serious injury or damage. · The applicable national safety regulations and accident prevention recommendations must be applied to all work carried on live variable speed starters. · The electrical installation must be carried out in accordance with the relevant electrical regulations (e. g. with regard to cable cross sections, fuses, PE). · Transport, installation, commissioning and maintenance work must be carried out only by qualified per- sonnel (IEC 60364, HD 384 and national occupational safety regulations). · Installations containing variable speed starters must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the variable speed starters using the operating software are permitted. · All covers and doors must be kept closed during operation. · To reduce the hazards for people or equipment, the user must include in the machine design measures that restrict the consequences of a malfunction or failure of the variable speed starter (increased motor speed or sudden standstill of motor). These measures include: • Other independent devices for monitoring safety related variables (speed, travel, end positions etc.). • Electrical or non-electrical system-wide measures (electrical or mechanical interlocks). • Never touch live parts or cable connections of the variable speed starter after it has been discon- nected from the power supply. Due to the charge in the capacitors, these parts may still be alive after disconnection. Consider appropriate warning signs. 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 4 Disclaimer The information, recommendations, descriptions, and safety notations in this document are based on Eaton’s experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the purchaser. THERE ARE NO UNDERSTAND- INGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLI- GATION OF EATON. THE CONTENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BETWEEN THE PARTIES. As far as applicable mandatory law allows so, in no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability, or otherwise for any special, indirect, incidental, or consequential damage or loss whatsoev- er, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the information, recommendations, and descriptions contained herein. The information contained in this manual is subject to change without notice. 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 5 General Devices of the series PowerXL™ DE1 are Variable Speed Starters for the supply of standard asyn- chronous motors. By default they are configured, that motors of the respective power class can be supplied without changing the settings. Many standard cases can be covered. There are some applications, which require an adaptation by changing parameters. In this Applica- tion Note the following aspects are covered: · Adaptation to the connected motor · Slip compensation · Motor protection · Setting the V/f curve · Energy optimization Motor data Condition for a proper operation is the right connection (star / delta) of the motor to the output ter- minals of the device. The rated voltage of the motor windings is decisive. Device Output Voltage Motor Connection DE1-12… 3 x 230 V 230 / 400 V Delta DE1-34… 3 x 400 V 230 / 400 V 400 / 660 V Star Delta DE1-34… 3 x 400 V 230 / 400 V Delta Special case: 87 Hz-curve (see Example 4 below) An adaptation to the connected motor can be done with the following parameters: · P-07 Motor Nom Voltage · P-08 Motor Nom Current · P-09 Motor Nom Frequency · P-10 Motor Nom Speed The respective values can be taken from the name plate of the motor or from the data sheet of the motor manufacturer. They are used for the setting of the motor protection and define the V/f curve. 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 6 Motor Nom Voltage (P-07) Motor rated voltage (name plate) taking the connection (star / delta) into account. This value defines the max. output voltage of the Variable Speed Starter. Is the output frequency higher than the rated frequency of the motor (P-09), the output voltage remains on the value set with P-07. See also chap- ter “V/f curve” below. Devices of the series DE1 have a voltage compensation. That means, that the output voltage is kept constant, even with fluctuation of the mains voltage. In case P-07 = 0 , the voltage compensation is disabled. In this case the maximum output voltage of the device is equal to the mains voltage at the input terminals. In exceptional cases, a different setting of P-07 is necessary. See chapter “87 Hz curve” PNU Parameter Name Range Default 211.0 P-07 Motor Nom Voltage 0 / 50 V … Ue Ue Ue = Rated voltage of the device, e.g. 230 V or 400 V, depending on device type Motor Nom Current (P-08) Rated current of the motor. By default, parameter P-08 „Motor Nom Current“ is set to the rated cur- rent Ie of the Variable Speed Starter. P-08 is also used to set the thermal protection for the motor. See also chapter “Motor Protection”. In case the rated current of the motor is different to the one of the Variable Speed Starter, P-08 has to be set accordingly to provide a thermal motor protection. It must be pointed out, that this current value is set, which is assigned to the type of connection of the motor. In the example above it is 3,2 A at 230 V (Delta) respectively 1,9 A at 400 V (Star). PNU Parameter Name Range Default 210.0 P-08 Motor Nom Current 0.1 · Ie … Ie Ie Ie = Rated current of the device Motor Nom Frequency (P-09) Rated frequency of the motor. By default this parameter is set to the mains frequency (50 Hz in Eu- rope, 60 Hz in USA) and doesn’t need to be changed in the majority of cases. In case, motors with rated frequencies different from the mains frequency (e.g. 200 Hz for fast rotat- ing motors) or if the 87 Hz curve is used, P-09 has to be set accordingly. PNU Parameter Name Range Default 216.0 P-09 Motor Nom Frequency 20 … 300 Hz 50 Hz resp. 60 Hz 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 7 Motor Nom Speed (P-10) (Switching from Hz to rpm, Slip compensation) P-10 = 0: Setting / display of the output frequency in Hz P-10 > 0: all speed related parameters (P-01, P-02, P-20…P-23) are set and displayed in rpm. Fur- thermore the slip compensation is activated, which ensures, that the motor speed is kept constant even with changing loads. In case the value of P-10 corresponds to a synchronous speed (e.g. 3000 rpm for a 2 pole motor at 50 Hz), the speed is set and displayed in rpm, but the slip compensation is not activated. With slip compensation Without slip compensation The slip is the difference between a synchronous speed because of a rotating field and the actual speed of the motor. The name plate in the example on page 5 shows a rated speed of 1410 rpm. It is a 4 pole motor with a synchronous speed of 1500 rpm. Between no load and rated load there is a slip of 90 rpm. Running the motor with a Variable Speed Starter, one wants to prevent the speed vari- ance by compensating the slip. With slip compensation: at load increase j voltage and frequency are increased accordingly k. The speed n1 remains constant. At load decrease voltage and frequency are reduced. Without slip compensation: with load j the speed drops from n1 to n2 k, when unloading the speed increases again. PNU Parameter Name Range Default 217.0 P-10 Motor Nom Speed 0 / 200 … 18000 rpm 0 rpm 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 8 Motor protection The Variable Speed Starters of the series DE1 own an internal motor protection function, which trips the drive after a certain time in case of overload. The display shows the fault message “I.t-trP“. The overload is related to the rated current of the motor, set with P-08. In case the output current of the device exceeds the value set with P-08 „Motor Nom Current“, this status is displayed on the keypad. 7-Segment LED display: dots a…f are flashing OLED display: text „O-L“ is displayed It has to be considered that, similar to a thermal overload relay, the current is used to estimate the temperature inside the motor. This kind of “indirect temperature measurement” is sufficient in many cases, but doesn’t reflect the real temperature conditions inside the motor. In case of Variable speed it has to be taken into account, that the cooling of the motor is done by an impeller, which is mount- ed on the motor’s shaft. Therefore the cooling is reduced at lower speeds. Experience shows that this is not critical between approx. 40 % and 100 % speed, but below 40 % it can lead to problems, if the application requires full torque also in this range (= full amount of losses). In pump and fan applica- tions where the torque is square with the speed, this effect is uncritical. In case of steady operation with nearly rated load below 40 % rated speed it is recommended to use motors with temperature sensors (thermistors or thermo contacts), which provide information about the real motor temperature. Thermistors as well as temperature contacts can be directly connected to DE1 devices. Example thermistor Example temperature contact Parameter P-15 has to be set in a way, that the function „External Fault“ (EXTFLT) is assigned to ter- minal 3 (DI3). During proper operation, a High-Signal is applied to terminal 3. In case of fault the temperature contact must open respectively the resistance of the thermistor has to increase. DE1 trips at a resistance of > 3.6 kΩ, Reset can be performed at values 100 % of the current set in P-08 for a certain time. · Check if the value of P-08 is equal to the motor rated current · Check motor connection (star / delta) · Flashing dots on the display indicate an operation with overload (> P- 08). Increase ramp time or decrease load in this case. · Check the load mechanically to ensure it is free and no jams, blockages or other mechanical faults exist. „Fault Code“ 5 x flash 2 s OFF O-t Heatsink overtemperature. The drive is too hot. · Check the ambient temperature around the drive is within the speci- fied range (maximum 50 °C / 60 °C, partly with derating) · Ensure sufficient cooling air is free to circulate around the drive (dis- tance to other devices above and below the variable speed starter). · Improve cooling of the control cabinet, when necessary. · The cooling slots may not be closed e.g. by pollution or by devices which are mounted too close „Fault Code“ 6 x flash 2 s OFF Internal fault in power section " Please refer to your next Eaton sales office. „Fault Code“ 7 x flash 2 s OFF SC-trp Loss of the serial communication · Check, if the connection to drives and other devices in the network is correct · Each participant in the network must have its own unique address. Two devices with the same address are not allowed. „Fault Code“ 8 x flash 2 s OFF P-dEf Default parameters have been loaded „Fault Code“ 9 x flash 2 s OFF Distorsion of the d.c. voltage „Fault Code“ 10 x flash 2 s OFF 4-20 F Analog input current out of range · Check settings of P-16 for AI1 · In case of 4-20mA: Check reference signal on wire break 2017-11-13 AP040029EN DE1 Starting, Stopping and Operation Page 19 Message Possible causes and remedy „Fault Code“ 11 x flash 2 s OFF U-t Undertemperature. This message is displayed, when the ambient temperature is below – 10 °C. To start the drive, the temperature must be above this value. „Fault Code“ 12 x flash 2 s OFF Th-flt Thermistor on the heatsink is faulty. Please refer to your next Eaton sales of- fice. „Fault Code“ 13 x flash 2 s OFF dAtA-F Fault in the internal memory. Parameters are not saved and default settings are reloaded. Try to save the (again modified) parameters again. If the message still appears: Please refer to your next Eaton sales office. 2017-11-13 AP040029EN DE1 Starting, Stopping and Operation Page 20 5 Stopping There are multiple possibilities to stop a variable speed drive: Possible with DE1? Accessories required Switch off, drive coasts to standstill YES None Ramp down to standstill YES None Ramp down to standstill with overvoltage control YES None Dynamic braking with brake resistor No - DC braking YES None Feedback energy to the mains NO - Mechanical brake (Variant DE11 only) YES None. Control with DE11 5.1 Ramping down or coasting? Parameter P-05 „Stop Mode“ determines, if the motor coasts or if it ramps down when the enable signal (FWD, REV, STOP) is removed. 5.1.1 Stop Mode (P-05) Coast to stop (P-05 = 0): When the enable signal is removed, the output of the inverter is disabled and the motor coasts to stop. Ramp to stop (P-05 = 1): When the enable signal is removed, the motor ramps to standstill with the ramp set with P-04. ATTENTION: In a drive system the energy always flows from the subsystem with the higher frequency to the one with lower frequency. If the output frequency of the variable speed starter is reduced too fast (deceleration ramp too short) and the motor still turns at a higher speed than the one corre- sponding to the output frequency of the inverter because of its inertia, the motor becomes a genera- tor and feeds back energy into the d.c. link. This leads to an increase of the d.c. link voltage and pos- sibly to a trip with the message O.Volt (Overvoltage). To prevent this, variable speed starters have the function “Overvoltage control”, which is enabled by default. More details see chapter 4.2.1. PNU Parameter Name Range Default 620.1 P-05 Stop Mode 0: coast to stop 1: ramp to stop 0 2017-11-13 AP040029EN DE1 Starting, Stopping and Operation Page 21 5.2 DC braking to standstill A DC current is injected into the motor, which generates a braking torque. The rotating energy of the machine is converted into heat, dissipated by the motor. This means that a DC braking must not be performed quite often, not to overload the motor. A DC braking cannot be used for a speed reduction e.g. from 1000 rpm to 800 rpm, but to a braking to standstill only. The DC braking is also used to stop rotating motors (e.g. fans, which turn because of the chimney effect inside a wind tunnel) before they start. This is to prevent overcurrent trips. See chapter 3.3 “Starting a rotating motor”. 5.2.1 DCBrake (P-25), t-DCBrake@Stop (P-26), DCBrake Voltage (P-27), f- DCBrake@Stop (P-28) Parameter P-25 „DCBrake“ determines, in which situations a DC braking is performed. In case a DC braking is required at stop, P-25 has to be set to 1 or 3. The behavior at removal of the signals FWD / REV / START depends on the stop mode (P-05). P-05 = 0 (coast to stop): The DC braking starts, once the signal FWD / REV / START is removed. P-05 = 1 (ramp to stop) At removal of FWD / REV / START the motor decelerates with the ramp set with “t-dec” (P-04). Once the frequency set with “f-DCBrake@Stop” (P-28) is reached, the DC braking starts. The strength and the duration depend on the settings of P-26 “t-DCBrake@Stop” and P-27 “DCBrake Voltage” (in percent of the motor rated voltage P-07). With P-25 = 3 it has to be noted, that the brak- ing time before a start is the same as after a stop. During a DC braking the LED „Fault code“ on the front of the variable speed starter lights yellow. 2017-11-13 AP040029EN DE1 Starting, Stopping and Operation Page 22 PNU Parameter Name Range Default 2221.0 P-25 DCBrake 0: OFF 1: ON at Stop 2: ON before Start 3: ON before Start and at Stop 0 2222.1 P-26 t-DCBrake@Stop 0.0…10 s 0.0 s 2220.0 P-27 DCBrake Voltage 0.0…100 % 0.0 % 2223.0 P-28 f-DCBrake@Stop 0 … P-01 (f-max) 0.0 Hz 2017-11-13 AP040029EN DE1 Starting, Stopping and Operation Page 23 5.3 Control of a mechanical brake HINT: The information is exclusively valid for the variant DE11! When a mechanical brake is used it should be activated at a certain speed. The relay contact be- tween the terminals 13 and 14 have the possibility to generate a speed dependent signal. The threshold is adjustable. It can be configured, if the relay contact closes above or below the threshold. Die Funktion des Ausgangs ist entsprechend zu konfigurieren. Kind of signal Terminals Function Threshold Normally open contact 13 / 14 P-51 „RO1 Function“ P-52 „RO1 Upper Limit“ 5.3.1 RO1 Funktion (P-51), RO1 obere Grenze (P-52) PNU Parameter Name Wertebereich Werk 451.0 P-51 RO1 Function 0: Drive running 1: Drive healthy 2: Motor at target speed 3: Drive tripped 4: Speed > RO1 Upper Limit (P-19) 5: Motor current > RO1 Upper Limit (P-19) 6: Speed < RO1 Upper Limit (P-19) 7: Motor current 0: all speed related parameters (P-01, P-02, P-20 … P-23) are set and displayed in rpm. PNU Parameter Name Range Default 217.0 P-10 Motor Nom Speed 0 / 200 … 30000 rpm 0 rpm 2017-11-10 AP040042EN DE1 Set Point Setting Page 6 1.2 Upper and lower speed limit The speed range of the connected motor is determined by the parameters “f-min” (P-02) and “f- max” (P-01). The reference is linear between these two values. Please note, that the value of P-01 cannot be exceeded, respectively the value of P-02 cannot be undercut. This is true for both senses of rotation. Frequency respectively speed = P-02 + (set pointactual / set pointmax) · (P-01 – P-02) Example 1: P-10 = 0 (setting / display in Hz) P-01 = 50 Hz P-02 = 0.0 Hz Set point via analog input: 0 … 10 V Set point actually set: 5 V Frequency = 0 Hz + (5 V / 10 V) · (50 Hz – 0 Hz) = 0 Hz + 0.5 · 50 Hz = 25 Hz Example 2: P-10 = 1470 rpm (setting / display in rpm) P-01 = 1470 rpm P-02 = 300 rpm Set point via analog input: 0 … 10 V Set point actually set: 5 V Speed = 300 rpm + (5 V / 10 V) · (1470 rpm – 300 rpm) = 300 rpm + 0.5 · 1170 rpm = 885 rpm PNU Parameter Name Range Default 20.1 P-01 f-max P-02 … 5 · P-09 (300 Hz max) 50.0 Hz 20.0 P-02 f-min 0.0 Hz … P-01 0.0 Hz Note: · With values of P-10 > 0 the setting is done in rpm instead of Hz. · The value, which can be set with P-01 „f-max“, is limited to five times „Motor Nom Frequen- cy“ (P-09) with a maximum of 300 Hz. 1.3 Behavior during change over between reference sources During a change over between two reference sources, e.g. from an analog signal to a fixed frequency, the new reference is approached with the actual ramp. The ramp times are determined by “t-acc” (P- 03) for acceleration and “t-dec” (P-04) for deceleration. 2017-11-10 AP040042EN DE1 Set Point Setting Page 7 1.4 Skip frequencies to avoid resonances In some applications an operation of the motor in a certain frequency band leads to mechanical res- onances, which can end up in a destruction of machine parts. The devices of the series PowerXLTM DE1… have the possibility to skip this frequency band for steady operation to avoid this effect. Fading out frequencies is possible with all kind of reference sig- nals, not depending on where they come from, e.g. analog input, fixed frequency, digital reference … , whatever is selected. The band width is determined by P-42 “f-SkipBand1”, while the center point is defined by P-43 “f-Skip1”. The diagram on the left hand side shows the behavior. Setting P-26 to zero, deactivates the function. REF = Reference Example: A motor runs up to 50 Hz. In the range between 15 Hz and 25 Hz mechanical resonances can occur. Therefore the motor may not run inside this range steadily. Band width: P-42 = 25 Hz – 15 Hz = 10 Hz Center point: P-43 = 15 Hz + 25 Hz 2 = 20 Hz How it works: The reference is below the disabled range. " Drive runs with the set frequency. " Increase of refer- ence into the disabled range " Motor accelerates and remains at the lower limit (in this example: 15 Hz). " Increase of reference above the disabled range " Motor accelerates with the ramp, set with P-03 “t-acc” to the new speed. " Motor operates above the disabled range according to the refer- ence. " Reduction of reference into the disabled area " Motor decelerates and remains at the up- per limit (in this example: 25 Hz). " Reduction of reference below the disabled area " Motor decel- erates with the ramp, set with P-04 “t-dec” to the new speed. PNU Parameter Name Range Default 22.0 P-42 f-SkipBand1 0…P-01 0 Hz1) 21.0 P-43 f-Skip1 0…P-01 0Hz1) 1) The default setting of P-10 “Motor Nom Speed” = 0. In this case the values for P-42 and P-43 are given in Hz. When P-10 is different from „0“, P-42 and P-43 have to be set in min-1. 2017-11-10 AP040042EN DE1 Set Point Setting Page 8 2 Analog reference Variable speed starters of the series DE1 have one analog input: · Analog input AI1 terminal 4 The configuration of the inputs and outputs is described inside the Application Note „I/O Configura- tion“ (AP040036EN). Beside the setting of the signal format (voltage or current), a scaling factor can be used to adopt the speed to the input signal. 2.1 Selecting the sense of rotation The analog value at terminal 4 determines the amount of speed. The control commands FWD and REV select clockwise or counter clockwise sense of rotation. If a change of sense is required, the actual command (e.g. FWD) has to be removed first, before applying the other one (e.g. REV). Applying FWD and REV simultaneously leads to a coasting of the motor. 2.2 Format of the analog value The speed reference signal can be a voltage signal as well as a current one. It is invertible with Pa- rameter P-18 in a way that a minimum signal leads to the maximum speed and vice versa. Format P-18 counter clockwise rotation clockwise rotation f-min f-max f-min f-max 0 … 10 V (U 0-10) 0 0 V + REV 10 V + REV 0 V + FWD 10 V + FWD 1 10 V + REV 0 V + REV 10 V + FWD 0 V + FWD 0 … 20 mA (A 0-20) 0 0 mA + REV 20 mA + REV 0 mA + FWD 20 mA + FWD 1 20 mA + REV 0 mA + REV 20 mA + FWD 0 mA + FWD 4 … 20 mA (t 4-20) 0 4 mA + REV 20 mA + REV 4 mA + FWD 20 mA + FWD 1 20 mA + REV 4 mA + REV 20 mA + FWD 4 mA + FWD 4 … 20 mA (r 4-20) 0 4 mA + REV 20 mA + REV 4 mA + FWD 20 mA + FWD 1 20 mA + REV 4 mA + REV 20 mA + FWD 4 mA + FWD Note: In case a terminal configuration without the commands FWD and REV is selected with P-15, the sense of rotation is set with the commands START and DIR. · Clockwise rotation " START · Counter clockwise rotation " START + DIR 2017-11-10 AP040042EN DE1 Set Point Setting Page 9 3 Fixed frequencies Fixed frequencies are references, which are set once, e.g. during commissioning and which can be selected by a digital command when required. The devices of the series DE1 have up to 4 fixed fre- quencies f-Fix1 … f-Fix4, which can be selected independently. 3.1 Setting the frequency value The setting of the fixed frequencies is done with P-20 up to P-23. Each value can be between zero and the maximum frequency „f-max“ (P-01). It has to be noted, that the minimum frequency “f-min” (P-02) will not be undercut, even when the fixed frequency is set to a lower value than P-02. Example: P-02 (f-min) = 10 Hz P-20 (f-Fix1) = 5 Hz When f-Fix1 is selected, the drive runs with 10 Hz! PNU Parameter Name Range Default 5.1 P-20 f-Fix1 0 … f-max (P-01) 20.0 Hz 5.2 P-21 f-Fix2 0 … f-max (P-01) 30.0 Hz 5.3 P-22 f-Fix3 0 … f-max (P-01) 40.0 Hz 5.4 P-23 f-Fix4 0 … f-max (P-01) 50.0 Hz 3.2 Selecting the sense of rotation When using a fixed frequency the sense of rotation is determined by the commands FWD (clockwise) and REV (counter clockwise) respectively DIR. 3.3 Selecting the fixed frequency The fixed frequencies can be activated via commands at the control terminals or via a field bus. The selection is binary coded " for 4 fixed frequencies 2 Bits (FF20 and FF21) are required. The predefined terminal configurations selected with P-15 enable access to the fixed frequencies. 3.3.1 Selection with predefined terminal configurations (P-15) 2017-11-10 AP040042EN DE1 Set Point Setting Page 10 Inside the Application Note „I/O Configuration“ (AP040036EN) the configuration of the control ter- minals is described. The following commands are important for the selection of fixed frequencies: Abbreviation Function FF1 Selection between the analog speed reference at analog input AI1 (ter- minal 6) and the fixed frequency 1 (f-Fix1), set with P-20. Low = analog reference, High = f-Fix1. FF20 / FF21 Selection of the digital frequencies f-Fix1 … f-Fix4 with digital commands FF20 FF21 f-Fix1 (P-20) L L f-Fix2 (P-21) H L f-Fix3 (P-22) L H f-Fix4 (P-23) H H 3.3.2 Use of fixed frequencies in device functions In certain situations, fixed frequencies are selected by a device function. Please take care, that there is no collision because of user specific settings. Fixed frequency Function f-Fix1 When P-16 = 4 (analog inputs with a signal 4 … 20 mA) the drive ramps to f-Fix1, in case of wire break in the reference circuit. 2017-11-10 AP040042EN DE1 Set Point Setting Page 11 4 Digital reference The speed reference of the variable speed starters DE1 can also be given via digital commands. The command UP (faster) increases the content of the reference counter, while DOWN (slower) reduces it. The use of a digital reference has the advantage, that the reference can be set from different loca- tions by paralleling push buttons, which is required in cases of large machines. The setting occurs between the minimum speed / frequency (f-min, P-02) and the maximum fre- quency / speed (f-max, P-01) with the actual ramp. The setting can be done with the keypad as well as via terminals. Example: · When an enabled drive gets the “UP” command, the motor accelerates according to the ac- tual ramp according to “t-acc” (P-03) · When the „UP“ command is removed, the speed remains constant. Applying “UP” again leads to a further acceleration. The maximum frequency / speed is defined with “f-max” (P- 01). · Consequently, applying „DOWN“ leads to a speed reduction. · When starting, the drive ramps to the speed determined by P-24 without an “UP” command. 2017-11-10 AP040042EN DE1 Set Point Setting Page 12 4.1 Configuration 4.1.1 Terminals / Keypad With the settings P-15 = 4, 5 or 6 UP and DOWN commands via terminals are possible. In case a key- pad DEX-KEY-LED is used, the reference value can be modified by using the arrow keys in addition. With P-12 = 1 or 2 the variable speed starter can be started and stopped with the keys on the key- pad. The behavior depends on the setting of P-24 “Digital Reference Reset Mode” (see 4.1.2) 4.1.2 Reference at start and at changeover between speed sources When starting a drive with a digital reference and when changing over from another speed source, e.g. a fixed frequency, to a digital reference the reference value to be ramped to is determined by the setting of P-24 “Digital Reference Reset Mode”: · P-24 = 0 or 2 o Minimum speed o Example 1: Behavior at start § Drive runs with digital reference " switch OFF " restart " drive ramps to the minimum speed, set with P-02 „f-min“. 2017-11-10 AP040042EN DE1 Set Point Setting Page 13 o Example 2: Behavior at changeover between speed sources § Drive runs with digital reference " Changeover to another speed source by applying a signal to the terminal " drive ramps to the speed required by the other speed source " Select “Digital reference” by removing the signal from the terminal " drive remains at the speed of the other speed source. The speed can now be changed with the keys on the keypad or with the signals UP and DOWN at the control terminals. · P-24 = 1 or 3 o Start with the latest speed before switching OFF or changing over to another speed source, set with the keypad or with the commands UP and DOWN at the terminals. This also applies to cases where another speed source was active at the time of switching OFF, but which is not selected at restart. o Example 1: The digital reference was set with the keypad to 1000 rpm. The speed source was changed from “Digital reference” to „Fixed Frequency 1“ by means of a command at the control terminals. The drive is switched OFF when “Fixed Frequen- cy1” is active. § Select „Digital reference“ at the terminals " drive ramps to the 1000 rpm set with the keypad § „Fixed Frequency 1“ was selected at the terminal when restarting " Drive ramps to Fixed Frequency 1 § Changeover to “Digital reference” with the signal at the terminals " drive ramps to 1000 rpm o Example 2: Switching OFF when the drive runs with another speed source than the digital reference § Selection of the other speed source is still active at restart " drive ramps to the speed of the other speed source. § Selection of the other speed source is not active at restart " drive ramps to the latest digital reference. P-24 „Digital Reference Reset Mode“ also determines, how the drive can be started when P-12 = 1 or 2: · P-24 = 0…1 o Starting of the drive by pushing the green START button on the keypad. § To start, an additional signal at the terminals is necessary (START / FWD / REV) · P-24 = 2…3 o The start of the drive is carried out via the terminals (see also 4.1.1). A start with the button on the keypad is not possible. o Note: With P-12 = 2 it is still possible to reverse the drive by pushing the green but- ton on the keypad. 2017-11-10 AP040042EN DE1 Set Point Setting Page 14 PNU Parameter Name Range Default 620.3 P-24 Digital Reference Reset Mode 0 / 1: START via keypad 0: Minimum speed (P-02) 1: Previous speed from Keypad / terminals (UP/DOWN) 2 / 3: START via terminals 2: Minimum speed (P-02) 3: Previous speed from Keypad / terminals (UP/DOWN) 1 4.2 Bedienung 4.2.1 Starting / Stopping Drives, which operate with a digital reference, can be started via terminals as well as via keypad. The possibilities depend on the setting of the parameters P-12 “Local ProcessData Source”, P-15 “DI Con- fig Select” and P-24 “Digital Reference Reset Mode”. Note: It can also be selected, that a signal from the terminal as well as one from the keypad must be ap- plied to start the drive. In this case the signal at the terminal must be present before the button on the keypad is pushed. P-12 P-24 P-15 Starting via terminal only Starting via keypad only Starting via terminal AND keypad P-12 = 0 P-24 = 0…3 P-15 = 4 / 5 / 6 YES NO NO P-12 = 1 / 2 P-24 = 0 / 1 P-15 = 0 … 9 NO NO YES P-24 = 2 / 3 P-15 = 0 … 9 YES* NO NO *In this case the keypad cannot be used to start the drive, but with P1-12 = 2 the green button can still be used to reverse it (see 4.2.3) 4.2.2 Increase / reduce speed When using a digital reference the speed is changed via the commands UP and DOWN. For the dura- tion of the commands the speed is increased respectively reduced. The commands are given via the keypad or via terminals. The behavior of the drive is depending on keypad or terminal adjustment. While a command via ter- minals modifies the speed with the actual ramp directly, an adjustment with the keypad has a slope and works more smoothly. This results in a delay of about 1.5 s for every actuation. With the setting of P-12 = 1 or 2 a speed adjustment via keypad is always possible, an adjustment via terminals only with the settings P-12 = 1 or 2 AND P-15 = 4 / 5 / 6. 2017-11-10 AP040042EN DE1 Set Point Setting Page 15 Note: · Simultaneous use of UP and DOWN (both via terminals or both via keypad) reduces the speed. · The terminal command dominates the one from the keypad. This also means: DOWN via keypad and UP via terminal " the speed increases. · A speed adjustment via keypad is also possible in cases where starting and stopping via key- pad is disabled. 4.2.3 Change sense of rotation The sense of rotation at start with a digital reference is basically determined by the terminal com- mands. With P12 = 2 one has the possibility to reverse the motor by pressing the green Start button on the keypad. Behavior at start: see column “Sense of rotation at START” in the table below. P-12 P-24 P-15 Sense of rotation via terminal Sense of rotation via keypad Sense of rotation at START P-12 = 0 P-24 = 0 … 3 P-15 = 4 / 5 NO NO No change of sense of rotation possible P-15 = 6 YES Sense of rotation as selected via terminals P-12 = 1 P-24 = 0 … 3 P-15 = 3 / 4 / 5 / 7 NO NO No change of sense of rotation possible P-15 = 8 / 9 YES (DIR) Sense of rotation as selected via terminals P-24 = 2 / 3 P-15 = 0 / 1 / 2 / 6 YES (FWD / REV) P-12 = 2 P-24 = 0 … 3 P-15 = 3 / 4 / 5 / 7 NO YES (INV) Sense of rotation as selected via termi- nals, taking into ac- count a possible in- version at the time of stopping the drive (Start button on the keypad). P-15 = 8 / 9 YES (DIR) P-24 = 2 / 3 P-15 = 0 / 1 / 2 / 6 YES (FWD / REV) Note: · P-15 = 0 / 1 / 2 / 6: o Applying the FWD and REV commands simultaneously leads to a coasting of the motor o In applications with reversion, the Stop Mode should be set in a way, that the ramp is active (P1-5 = 1). If this is not the case a changeover between the com- mands FWD and REV is detected as stop command and the drive behaves ac- cording the setting with P-05. After this, it restarts into the opposite direction. Starting a motor, which is still turning can lead to an overcurrent trip. · P-12 = 2 o A possible inversion with the Start button on the keypad is stored at stop. The drive restarts with the same sense of rotation he had before stopping. Please note, that in this case the sense of rotation at restart cannot be clearly defined by the terminal commands.. www.eaton.eu Application Note 11/2017 AP040036EN PowerXL™ DE1 Variable Speed Starter I/O Configuration Level 2 1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended 2017-11-13 AP040036EN DE1 I/O Configuration Page 2 Contents 1 General

2017-11-13 AP040036EN DE1 I/O Configuration Page 3 Danger! - Dangerous electrical voltage! • Disconnect the power supply of the device. • Ensure that devices cannot be accidentally restarted. • Verify isolation from the supply. • Cover or enclose any adjacent live components. • Follow the engineering instructions (AWA/IL) for the device concerned. • Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system. • Before installation and before touching the device ensure that you are free of electrostatic charge. • The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection. • Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automatic control functions. • Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states. • Deviations of the mains voltage from the rated value must not exceed the toleranc e limits give n in the specification, otherwise this may cause malfunction and/or dangerous operation. • Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes. Unlatch- ing of the emergency-stop devices must not cause a restart. • Devices that are designed for mounting in housings or control cabinets must only be oper ated and c on- trolled after they have been properly installed and with the housing closed. • Wherever faults may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, me - chanical interlocks etc.). • Variable speed starters may have hot surfaces during and immediately after operation. • Removal of the required covers, improper installation or incorrect operation of motor or var iable spe ed starter may destroy the device and may lead to serious injury or damage. • The applicable national safety regulations and accident prevention recommendations must be applied to all work carried on live variable speed starters. • The electrical installation must be carried out in accordance with the relevant electrical regulations (e . g. with regard to cable cross sections, fuses, PE). • Transport, installation, commissioning and maintenance work must be carried out only by qualified per - sonnel (IEC 60364, HD 384 and national occupational safety regulations). • Installations containing variable speed starters must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the variable speed star te rs using the operating software are permitted. • All covers and doors must be kept closed during operation. • To reduce the hazards for people or equipment, the user must include in the machine design me asure s that restrict the consequences of a malfunction or failure of the variable speed starter (incre ased motor speed or sudden standstill of motor). These measures include: • Other independent devices for monitoring safety related variables (speed, travel, e nd positions etc.). • Electrical or non-electrical system-wide measures (electrical or mechanical interlocks). • Never touch live parts or cable connections of the variable speed starter after it has been disc on- nected from the power supply. Due to the charge in the capacitors, these parts may still be alive after disconnection. Consider appropriate warning signs. 2017-11-13 AP040036EN DE1 I/O Configuration Page 4 Disclaimer The information, recommendations, descriptions, and safety notations in this document are based on Eaton’s experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the pur- chaser. THERE ARE NO UNDERSTANDINGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IM- PLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTA- BILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLIGATION OF EATON. THE CON- TENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BE- TWEEN THE PARTIES. As far as applicable mandatory law alLows so, in no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability, or otherwise for any special, indirect, incidental, or consequential damage or loss whatsoev- er, including but not limited to damage or loss of use of equipment, plant or power sy stem, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the infor- mation, recommendations, and descriptions contained herein. The information contained in this manual is subject to change without notice. 2017-11-13 AP040036EN DE1 I/O Configuration Page 5 1 General The variable speed starters of the series PowerXLTM DE1 are configured for many applications by default. In addition there is the possibility to adopt the devices to the application. Not only internal variables like ramp times or speed are changed, but also different functions can be assigned to the terminals. This possibility is universal inside the DE1 series and does not depend on the power rating. This Application Note describes • the existing input and output terminals • the technical data • the assignment of functions to terminals • the configuration of the I/Os Wiring diagram of a variable speed starter DE1 with default settings 2017-11-13 AP040036EN DE1 I/O Configuration Page 6 2 Hardware All signals at the input terminal have the same signal common (0 V). Terminal 4 can be used as digital input as well as analog input. The respective function depends on the configuration (see chapter 3ff). 2.1 Designation of the control terminals and technical data Designation Function Default 0 V Signal common for all inputs (terminals. 1 … 4) - + 10 V Control voltage and reference voltage 20 mA max. Signal common: 0 V - 1 (DI1) Digital input 1 HIGH: 9 … 30 V 10 V: 1,15 mA / 24 V: 3 mA FWD 2 (DI2) Digital input 2 HIGH: 9 … 30 V 10 V: 1,15 mA / 24 V: 3 mA REV 3 (DI3) Digital input 3 HIGH: 9 … 30 V 10 V: 0,12 mA / 24 V: 0,3 mA FF1 4 (AI1 / DI4) Analog input 1 or digital input 4 analog: 0 … 10 V; 0,12 mA 0/4 … 20 mA, RB = 500 Ω digital: HIGH: 9 … 30 V 10 V: 0,12 mA / 24 V: 0,3 mA REF (analog, 0 … 10 V) 13 Relay RO1 (NO) 250 V, 6 A AC / 30 V, 5 A DC RUN, device enabled14 2.2 Wiring examples The control terminals of the devices DE1 are fixed. On the variant DE11, the terminal block for the control signals is pluggable. To apply control signals to the terminals, the internal 10 V as well as ex- ternal voltages, e.g. 24 V from a PLC, can be used. 2.2.1 Example 1: Application motor starter 2017-11-13 AP040036EN DE1 I/O Configuration Page 7 2.2.2 Example 2: Application with variable speed 2.2.3 Example 3: Control voltage from an external voltage source 2017-11-13 AP040036EN DE1 I/O Configuration Page 8 2.2.4 Example 4: external reference value 2.2.5 Example 5: control by a PLC 2017-11-13 AP040036EN DE1 I/O Configuration Page 9 2.3 Relay output Depending on the kind of load, we recommend the use of protection circuitry for the relay outputs. 2017-11-13 AP040036EN DE1 I/O Configuration Page 10 3 Configuration The table gives an overview, how to determine the function of the single I/Os. Designation Selection / setting of Function Format (signal range) Scaling (Gain) Inversion Hysteresis Offset 0 V fixed - - - - - +10 V fixed - - - - - 1 (DI1) P-12 / P-15 - - - - - 2 (DI2) - - - - - 3 (DI3) - - P-19 - - 4 (AI1 / DI4) P-16 P-17 P-18 - P-44 DE1: 13 fixed - - - - - DE1: 14 - DE11: 13 P-51 - - - P-52 / P-53 / P-54 - DE11: 14 3.1 Inputs The function of the inputs can be configured in different ways: • using the default settings. • configuration with the configuration module DXE-EXT-SET. The numbers at the selector switch correspond to the settings of P-15 in terminal mode (P-12 = 0) • via the optional keypad DX-KEY-LED • via the parameter software DrivesConnect The available terminal combinations depend on the selection of the “Local ProcessData Source” (P- 12). Default: P-15 = 0, P-12 = 0. 3.1.1 Terminal configuration PNU Parameter Name Range Default 423.0 P-15 DI Config Select 0 … 9 0 2017-11-13 AP040036EN DE1 I/O Configuration Page 11 2017-11-13 AP040036EN DE1 I/O Configuration Page 12 2017-11-13 AP040036EN DE1 I/O Configuration Page 13 2017-11-13 AP040036EN DE1 I/O Configuration Page 14 For the terminal functions the following abbreviations are used: Abbreviation Function DIR Used for the selection of the sense of rotation in connection with the START command. Low = cw (FWD) High = ccw (REV) ATTENTION: in case of a wire break the drive reverses in case REV is selected! Alternative: use configuration with FWD/REV. DOWN “Reduce speed” command, when a digital reference is selected. Used in combination with the command UP. In case UP and DOWN are ap- plied simultaneously. The motor reduces its speed for the duration of the simultaneous signals with the deceleration ramp set with “t-dec” (P-04). ENA Enable variable frequency drive. To start the drive an additional start signal (START, FWD, REV) is necessary. When removing ENA, the mo- tor coasts to stop. ENAINV In case ENAINV is used instead of ENA, the sense of rotation is invert- ed, compared to the one determined by a keypad or a fieldbus. Example: ENA + FWD = FWD, ENAINV + FWD = REV ENAREF Enable signal for the speed reference. This signal is necessary to oper- ate the variable speed starter in addition to START respectively FWD/REV. At disconnection of ENAREF the variable speed starter ramps to stand still, but the variable speed starter will not be disa- bled. EXTFLT External fault. Enables the inclusion of an external signal into the fault messages of the variable speed starter. P-19 = 0: During operation a High signal must be applied to the termi- nal. A Low signal leads to a trip with the message “E-trip”. P-19 = 1: During operation a Low signal must be applied to the termi- nal. A High signal leads to a trip with the message “E-trip”. FF1 Selection between the analog speed reference at analog input AI1 (terminal 4) and the fixed frequency 1 (f-

Fix1), set with P-20. Low = analog reference, High = f-Fix1 FF20 / FF21 Selection of the fixed frequency with digital commands. The fixed frequencies f-Fix1 … f-Fix4 are defined with P-20 … P-23. FF20 FF21 f-Fix1 (P-20) L L f-Fix2 (P-21) H L f-Fix3 (P-22) L H f-Fix4 (P-23) H H FWD START with a clockwise rotating field (FWD = Forward). When applying a High signal to the respective terminal, the motor accelerates with the predefined ramp. Removing the signal leads to a stop. The stop behavior depends on the setting of P-05 "Stop Mode". At standstill the variable speed starter is disabled. In applications with two direc- tions, counter clockwise rotation is selected with REV. FWD and REV are logically connected (XOR). Applying both signals at the same time leads to a trip of the variable speed starter. 2017-11-13 AP040036EN DE1 I/O Configuration Page 15 Abbreviation Function REF Analog input AI1 (terminal 4) is used as speed reference input. P-16: Format (voltage input / current input …) P-17: Scaling P-18: Inversion REV START with a counter clockwise rotating field (REV = Reverse). When applying a High signal to the respective terminal, the motor acceler- ates with the predefined ramp. Removing the signal leads to a stop. The stop behavior depends on the setting of P-05 "Stop Mode". At standstill the variable speed starter is disabled. In applications with two directions, clockwise rotation is selected with FWD. FWD and REV are logically connected (XOR). Applying both signals at the same time leads to a trip of the variable speed starter. START Starts and stops the motor. When applying a High signal to the re- spective terminal, the motor accelerates with the predefined ramp. Removing the signal leads to a stop. The stop behavior depends on the setting of P-05 "Stop Mode". At standstill the variable speed start- er is disabled. In applications with two directions, the sense of rota- tion is selected with DIR or INV.In applications with Smartwire DT this signal is necessary in addition to the start command coming via bus. UP "Increase speed" command, when a digital reference is selected. Used in combination with the command DOWN. In case UP and DOWN are applied simultaneously. The motor reduces its speed for the duration of the simultaneous signals with the deceleration ramp set with "t- dec" (P-04). 3.1.2 Displaying input signals The status of the inputs can be displayed by selecting the respective parameters. PNU Parameter Name Range Default 560.0 P00-01 Analog input1 0.0 … 100 % input signal - 550.0 … 550.3 P00-04 DI1 Status 0 / 1 - The value, displayed with P00-01, takes also a potential scaling factor (P-17) into account. Example: P00-01 = Signal at AI1 [%] · P-17 The display on the keypad can be used to see the status of the digital inputs DI1 … DI4. It starts with DI1 on the left hand side of the display. 0 = Low signal, 1 = High signal at the respective input termi- nal. Voltages between 9 and 30 V are identified as High signal. If an input is configured as analog input, its status is displayed in P00-04 with 0 with voltage levels up to 9 V, above this with 1. 2017-11-13 AP040036EN DE1 I/O Configuration Page 16 3.1.3 Configuration of digital input DI3 Digital input 3 (Terminal 3) can be used to include an external signal into the fault messages. Parame- ter P-19 (DI3 Logic) determines, if a HIGH or a LOW signal is necessary at terminal 3 to indicate a proper status. PNU Parameter Name Range Default 650.2 P-19 DI3 Logic 0 " HIGH = OK, LOW = fault 1 " LOW = OK, HIGH = fault 0 DI3 can be configured in a way, that a thermistor can be used to protect the connected motor. In this case P-19 must be set to 0. Parameter P-15 has to be set in a way, that the function „External Fault" (EXTFLT) is assigned to terminal 3 (DI3). During proper opera- tion, a High-Signal is applied to terminal 3. In case of fault the tem- perature contact must open respectively the resistance of the ther- mistor has to increase. DE1 trips at a resistance of > 3.6 kΩ, Reset can be performed at values "RO1 Upper Limit" , output will be logic 0 if value "RO1 Upper Limit" , output will be logic 1 if value RO1 Upper Limit (P-52) 5: Motor current > RO1 Upper Limit (P-52) 6: Speed < RO1 Upper Limit (P-52) 7: Motor current 3.6 kΩ, Reset can be performed at values "RO1 Upper Limit" , output will be logic 0 if value "RO1 Upper Limit" , output will be logic 1 if value RO1 Upper Limit (P-52) 5: Motor current > RO1 Upper Limit (P-52) 6: Speed < RO1 Upper Limit (P-52) 7: Motor current < RO1 Upper Limit (P-52) 8: DE1 not enabled 9: Speed not at speed reference value 0 452.0 P-52 RO1 Upper Limit 0.0 … 200.0 % 100.0 % 454.0 P-53 RO1 Hysteresis 0.0 … 100.0 % 0.0 % 457.0 P-54 RO1 Switch-On Delay 0.0 … 250.0 s 0.0 s Application Note 07/2022 AP040184EN PowerXL DG1 – Firmware Update Level 3 1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended 2 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com All proprietary names and product designations are brand names or trademarks registered to the relevant title holders. Services For service and support, please contact your local sales organisation. Contact details: Eaton.com/contacts Service page: Eaton.com/aftersales Original Application Note Original document is the German version of this document. Translation All non-German language versions of this document are translations of the original application note. 1. Edition 2022, publication date 07/2022 © 2021 by Eaton Industries GmbH, 53115 Bonn All rights reserved, also for the translation. No part of this document may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, micro-filming, recording or otherwise, without the prior written permission of Eaton Industries GmbH, Bonn. Subject to alteration. Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 3 DANGER! DANGEROUS ELECTRICAL VOLTAGE! • Disconnect the power supply of the device. • Ensure that devices cannot be accidentally restarted. • Verify isolation from the supply. • Ground and short-circuit. • Cover or enclose any adjacent live components. • Follow the engineering instructions (AWA/IL) for the device concerned. • Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system. • Before installation and before touching the device ensure that you are free of electrostatic charge. • The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection. • Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automatic control functions. • Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states. • Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specification, otherwise this may cause malfunction and/or dangerous operation. • Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes. Unlatching of the emergency-stop devices must not cause a restart. • Devices that are designed for mounting in housings or control cabinets must only be operated and controlled after they have been properly installed and with the housing closed. • Wherever faults may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, mechanical interlocks etc.). • The used device may have hot surfaces during and immediately after operation. • Removal of the required covers, improper installation or incorrect operation of motor or device may destroy the device and may lead to serious injury or damage. • The applicable national safety regulations and accident prevention recommendations must be applied to all work carried on live device. • The electrical installation must be carried out in accordance with the relevant electrical regulations (e. g. with regard to cable cross sections, fuses, PE). • Transport, installation, commissioning and maintenance work must be carried out only by qualified personnel (IEC 60364, HD 384 and national occupational safety regulations). • Installations containing device must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the device using the operating software are permitted. • All covers and doors must be kept closed during operation. • To reduce the hazards for people or equipment, the user must include in the machine design measures that restrict the consequences of a malfunction or failure of the device (increased motor speed or sudden standstill of motor). These measures include: – Other independent devices for monitoring safety related variables (speed, travel, end positions etc.). – Electrical or non-electrical system-wide measures (electrical or mechanical interlocks). – Never touch live parts or cable connections of the device after it has been disconnected from the power supply. Due to the charge in the capacitors, these parts may still be alive after disconnection. Consider appropriate warning signs. 4 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com Disclaimer The information, recommendations, descriptions, and safety notations in this document are based on Eaton's experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the purchaser. THERE ARE NO UNDERSTANDINGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLIGATION OF EATON. THE CONTENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BETWEEN THE PARTIES. As far as applicable mandatory law allows so, in no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability, or otherwise for any special, indirect, incidental, or consequential damage or loss whatsoever, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the information, recommendations, and descriptions contained herein. The information contained in this manual is subject to change without notice. Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 5 Content General .... 6 Connecting the Drive to a PC... 6 Apply main voltage .... 6 Firmware Upgrade... 7 Resetting to default settings .... 11 Firmware Upgrade for optional cards .... 12 6 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com General The device software of the DG1 can be updated to a newer version or downgraded to an old one. Both is done via the so-called firmware update tool. Connecting the Drive to a PC 1. Remove the front cover. 2. Connect the programming cable to terminals 25 and 26. Abbildung 1: Connecting the programming cable Apply main voltage Start the drive by applying the main voltage. Depending on frame size: 230V AC a single phase: L1(L)/L3(N) 400V AC a three phase: L1/L2/L3 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 7 Firmware Upgrade 1. First download the desired firmware package from the Eaton website and unzip the file. Abbildung 2: Firmware package 2. Open the Firmware Upgrade Tool. Abbildung 3: Firmware Upgrade Tool 3. Select the previously downloaded firmware package from your directory by clicking "Browse". Abbildung 4: Power Xpert inControl Software 4. Select the file "DG1_C0033". Abbildung 5: DG1_C0033 5. Check the cable connection and the COM port in the Windows Device Manager. 8 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com Abbildung 6. Enter "1" for "Slave Address" and select the COM port. Abbildung 7: Settings 7. Establish the connection via "Connect". Abbildung 8: Establish connection 8. After the firmware has been detected, a dialog for confirming the firmware package is shown. The tool automatically sets check marks once the version differences have been detected. Abbildung 9: Update process 9. Choose „Block 0" for german and „Block 1" for english. Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 9 Abbildung 10: Update process 10. Confirm the selection with „Program". Abbildung 11: Confirming 11. Verify that the update has been completed correctly. ("Programming Success - Verification OK"). If "Verification OK" appears, select "Disconnect". If "Failed" appears, repeat the update process or contact After Sales Service. 10 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com Abbildung 12: Update completed Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 11 Resetting to default settings Reset all parameter to the factory settings by proceeding as follows: Parameters à Basic Settings à System à Parameter Sets (P21.1.3) Then select "Reload defaults". Abbildung 13: Parameter reset Now the firmware update is completed. You can disconnect the programming cable, remove the power connector and reattach the front cover. 12 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com Firmware Upgrade for optional cards 1. Connect the optional module to one of the expansion slots. Abbildung 14: Installing expansions 2. Follow the steps 2.1 to 4.8. 3. Confirm the selection with „Program". Abbildung 15: Confirming the selection 4. Check the update version of the board. If "Code is same" appears, no update needs to be performed here. Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 13 Abbildung 16: Check the version 5. Click „Disconnect" to disconnect the communication again. If the drive now remains in "Loader Mode", a connection should be established again via "Connect" and then disconnected again via "Disconnect". If the drive is still in "Booth Loader Mode" as well as "Startup Wizard" does not appear, please contact After Sales Service. Eaton Industries GmbH Hein-Moeller-Str. 7- 11 D-53115 Bonn © 2020 Eaton Corporation . Alle Rechte vorbehalten 07/2022 AP040184EN Eaton is dedicated to ensuring that reliable, efficient and safe power is available when it's needed most. With vast of energy management experts at Eaton deliver customized, integrated solutions to solve our customers' most critical challenges. Our focus is on delivering the right solution for the Application. But decision makers demand more than just Innovative products. They turn to Eaton for an unwavering Commitment to personal support that makes customer Success a top priority. For more information, visit Eaton.com Eaton addresses worldwide: Eaton.com/contacts www.eaton.eu Application Note 04/2017 AP040168EN PowerXL™ DG1 Variable Frequency Drives Load balancing in multi motor applications Level 1 1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 2 Contents 1 General .... 5 2 Load balancing via slip .... 6 3 Load balancing via drooping... 7 3.1 Application example .... 8 4 Adjustable load balancing via torque control .... 9 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 3 Danger! - Dangerous electrical voltage! · Disconnect the power supply of the device. · Ensure that devices cannot be accidentally restarted. · Verify isolation from the supply. · Cover or enclose any adjacent live components. · Follow the engineering instructions (AWA/IL) for the device concerned. · Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system. · Before installation and before touching the device ensure that you are free of electrostatic charge. · The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection. · Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automatic control functions. · Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states. · Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specification, otherwise this may cause malfunction and/or dangerous operation. · Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes. Unlatch- ing of the emergency-stop devices must not cause a restart. · Devices that are designed for mounting in housings or control cabinets must only be operated and con- trolled after they have been properly installed and with the housing closed. · Wherever faults may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, me- chanical interlocks etc.). · Frequency inverters may have hot surfaces during and immediately after operation. · Removal of the required covers, improper installation or incorrect operation of motor or frequency invert- er may destroy the device and may lead to serious injury or damage. · The applicable national safety regulations and accident prevention recommendations must be applied to all work carried on live frequency inverters. · The electrical installation must be carried out in accordance with the relevant electrical regulations (e. g. with regard to cable cross sections, fuses, PE). · Transport, installation, commissioning and maintenance work must be carried out only by qualified per- sonnel (IEC 60364, HD 384 and national occupational safety regulations). · Installations containing frequency inverters must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the frequency inverters us- ing the operating software are permitted. · All covers and doors must be kept closed during operation. To reduce the hazards for people or equipment, the user must include in the machine design measures that restrict the consequences of a malfunction or failure of the frequency inverter (increased motor speed or sud- den standstill of motor). These measures include: – Other independent devices for monitoring safety related variables (speed, travel, end positions etc.). – Electrical or non-electrical system-wide measures (electrical or mechanical interlocks). – Never touch live parts or cable connections of the frequency inverter after it has been disconnected from the power supply. Due to the charge in the capacitors, these parts may still be alive after disconnection. Consider appropriate warning signs. 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 4 Disclaimer The information, recommendations, descriptions, and safety notations in this document are based on Eaton's experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the purchaser. THERE ARE NO UNDERSTAND- INGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLI- GATION OF EATON. THE CONTENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BETWEEN THE PARTIES. As far as applicable mandatory law allows so, in no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability, or otherwise for any special, indirect, incidental, or consequential damage or loss whatsoev- er, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the information, recommendations, and descriptions contained herein. The information contained in this manual is subject to change without notice. 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 5 1 General In cases, in which multiple motors are fixed permanently our coupled via friction, an equal load shar- ing between the motors is required. Already small differences in the mechanical structure of the drives inside the system or manufacturing tolerances can lead to an unbalanced load sharing. Beside an oversizing other measures exist to balance the load to ensure a reliable operation of the applica- tion and to prevent overload situations for single motors. Like in many other cases, multiple solutions exist, differing in complexity and costs. There is a funda- mental interest to choose the variant with the best value for money. In the end the application de- termines, which kind of solution can be chosen. This application note describes three of the possible solutions in connection with variable frequency drives and provides an indication of the right solu- tion. The following chapters describe, how the different solutions work. The table below gives an overview about the substantial features and differences. Control via slip Droop function Torque control Control mode Speed control Speed control 1 motor with speed control, the other ones with torque control Number of variable frequency drives 1 variable frequency drive per motor; con- necting multiple mo- tors in parallel to the output of one device is possible. 1 variable frequency drive per motor 1 variable frequency drive per motor Load balancing via Slip Load dependent corrective value Torque control Accuracy of balancing + ++ +++ Motors (power, manufacturer) Equal motors necessary Different motors possible Different motors possible Mechanical coupling between the motors Preferably coupled via friction; fixed mechan- ical coupling possible in some applications. Preferably coupled via friction; fixed mechan- ical coupling possible in some applications. Fixed coupling and coupling via friction possible. In case of coupling via friction a speed limitation is recommended. 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 6 2 Load balancing via slip The speed of a three phase induction motor depends on the load. When it is supplied with the voltage and frequency ac- cording to its name plate, an unloaded motor turns with near- ly synchronous speed, while the speed at rated load corre- sponds to the rated speed. In case of a 50 Hz mains supply and a four pole motor this means, that the unloaded motor turns with approximately 1500 rpm and at rated load e.g. with 1470 rpm. The difference between synchronous speed and the speed of the motor axis is called slip. In the example on the left the motor is loaded with torque M1 and it turns with the speed n1. The load is increased up to M2 j´ The speed drops down to n2 k. This behavior is utilized in a slip dependent load balancing. This simplest kind of "automatic" load sharing presumes, that the mechanics as well as the motors of all parts of the system are identical. In theory all motors have to carry the same load per definition, but tolerances, temperature dependen- cy and small mechanical differences let the loads drift apart, even when the motors were equally loaded at the point of start. But how does load balancing work? The motor with the highest load drops in speed and in this case the other one(s) have to carry more load than before. The load is now more or less balanced. There is no possibility for load adjustment and the sharing is defined by the system. Therefore it makes sense to add some margin when calculating the motor powers. The variable frequency drive DG1 has to work in the motor control mode "Freq Control" (P8.1 = 0). In case each motor has its own variable frequency drive, they must have identical parameter settings. Parameter Name Range Default P8.1 Motor Control Mode Freq Control (0) Speed Control (1) Open Loop Speed Control (5) Open Loop Torque Control (6) Freq Control (0) Application Note It is also possible to connect multiple motors in parallel to one variable frequency drive. It has to be noted, that each motor must have its own motor protection, because the total current is "known" by the variable frequency drive, but not how it is shared between the single motors. 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 7 3 Load balancing via drooping In case speed controlled drive systems are mechanically connected through form fit or friction, the fastest drive takes the load and pulls the other ones, which are less, or in extreme cases, not loaded. To counteract this effect, the speed reference will be corrected, depending on the load. At load in- crease, the droop function reduces the resulting speed reference (set reference – speed reduction), the motor falls back a little bit in its speed and the other motors inside the system take more load automatically. Application experience shows, that it is of advantage in many cases to have one motor inside the system, where the droop function is disabled (P8.13 "Load Drooping" = 0.00 %), while it is enabled (P8.13 "Load Drooping" different from 0.0 %) for all other motors inside the system. The set value of P8.13 is the percentage of speed by which the speed drops in case the motor is loaded with rated torque. With reduced load, the speed reduction will be reduced accordingly. In exceptional cases it can also be advantageous to enable the droop function for all motors. The variable frequency drive DG1 has to work in the motor control mode "Open Loop Speed Control" (P8.1 = 5) to achieve the best result. Parameter Name Range Default P8.1 Motor Control Mode Freq Control (0) Speed Control (1) Open Loop Speed Control (5) Open Loop Torque Control (6) Freq Control (0) P8.13 Load Drooping 0.00 % … 100.00 % 0.00 % 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 8 3.1 Application example Material is transported through the machine by means of two conveyor belts. Each belt is driven by its own motor. Because of the contact pressure, the two belts are connected mechanically. In case one of the two mo- tors tries to run a little bit faster than the other one, it leads to an unequal load sharing. Without an enabled droop function, motor 1 takes 80 % of its rated load, motor 2 85 %. Because of the higher load, motor 2 becomes warmer than motor 1, possibly one can also see the difference in speed on the material which is transported between the belts. Now the droop function will be enabled with P8.13. The system will change to equal load sharing iteratively. Values at the beginning (we are looking to the system at an output frequency of 40 Hz, P1.9 = 50 Hz, P8.13 = 10.00 %): Resulting speed of motor 1: 40 Hz – ((10 % · 50 Hz) · 80 %) = 36 Hz Resulting speed of motor 2: 40 Hz – ((10 % · 50 Hz) · 85 %) = 35,75 Hz Motor 2 now runs slower than motor 1 " The load of motor 1 increases " Therefore the load of motor 2 is reduced ……. This is a repetitive process until an equal sharing of the load is achieved. Remaining differences in load can be adjusted with 8.13. 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 9 4 Adjustable load balancing via torque control Inside this system, one motor is speed controlled and the other one(s) torque controlled. The speed controlled motor determines the speed of the system, while the torque is the control variable for the other motors. Here it is possible to use motors of different ratings and it is also possible to set indi- vidual shares of the load. A torque control is much more complex than the principles described in chapters 2 and 3. On the other hand you have much more possibilities to adopt the control to the application, which results in a higher accuracy. Nevertheless the other principles are useful in simple applications because of their simplicity and value for money. Torque control is extensively described inside the application Note „AP040167EN Torque Control". Please refer to this document. One important aspect must be mentioned here: A torque controlled motor always tries to bring the required torque (or tension in case of linear movements) to the load. When this is not possible, the torque is used for acceleration to the maximum possible speed. This is not critical as long as the mo- tors are connected together mechanically, e.g. when all pinions work on the same geared ring. In cases where the speeds of the motors involved are not synchronized mechanically and a slip in speed is possible, it is strongly recommended to limit the speed of the torque controlled motor. The neces- sary aspects and settings are comprehensively described in the application note AP040167EN men- tioned above. www.eaton.eu Application Note 01/2018 AP040177EN DE PowerXL™ DG1 Variable Frequency Drives Motor data and V/f curves Level 2 1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 2 Contents 1 General .... 5 2 Motor data .... 5 2.1 Motor Nom Current .... 6 2.2 Motor Nom Speed .... 6 2.3 Motor PF .... 6 2.4 Motor Nom Voltage .... 6 2.5 Motor Nom Frequency .... 7 2.6 Motor Identification .... 7 3 Motor Control Mode .... 9 3.1 Frequency Control (V/f)... 9 3.2 Speed Control .... 9 3.3 Open Loop Speed Control .... 10 4 V/f curve .... 11 4.1 Optimizing the V/f curve at Frequency Control and Speed Control .... 12 4.1.1 Improving the torque behavior .... 13 4.1.2 Increasing energy efficiency .... 15 4.2 87 Hz curve .... 15 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 3 Danger! - Dangerous electrical voltage! · Disconnect the power supply of the device. · Ensure that devices cannot be accidentally restarted. · Verify isolation from the supply. · Cover or enclose any adjacent live components. · Follow the engineering instructions (AWA/IL) for the device concerned. · Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system. · Before installation and before touching the device ensure that you are free of electrostatic charge. · The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection. · Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automatic control functions. · Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states. · Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specification, otherwise this may cause malfunction and/or dangerous operation. · Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes. Unlatch- ing of the emergency-stop devices must not cause a restart. · Devices that are designed for mounting in housings or control cabinets must only be operated and con- trolled after they have been properly installed and with the housing closed. · Wherever faults may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, me- chanical interlocks etc.). · Frequency inverters may have hot surfaces during and immediately after operation. · Removal of the required covers, improper installation or incorrect operation of motor or frequency invert- er may destroy the device and may lead to serious injury or damage. · The applicable national safety regulations and accident prevention recommendations must be applied to all work carried on live frequency inverters. · The electrical installation must be carried out in accordance with the relevant electrical regulations (e. g. with regard to cable cross sections, fuses, PE). · Transport, installation, commissioning and maintenance work must be carried out only by qualified per- sonnel (IEC 60364, HD 384 and national occupational safety regulations). · Installations containing frequency inverters must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the frequency inverters us- ing the operating software are permitted. · All covers and doors must be kept closed during operation. To reduce the hazards for people or equipment, the user must include in the machine design measures that restrict the consequences of a malfunction or failure of the frequency inverter (increased motor speed or sud- den standstill of motor). These measures include: – Other independent devices for monitoring safety related variables (speed, travel, end positions etc.). – Electrical or non-electrical system-wide measures (electrical or mechanical interlocks). – Never touch live parts or cable connections of the frequency inverter after it has been disconnected from the power supply. Due to the charge in the capacitors, these parts may still be alive after disconnection. Consider appropriate warning signs. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 4 Disclaimer The information, recommendations, descriptions, and safety notations in this document are based on Eaton's experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the pur- chaser. THERE ARE NO UNDERSTANDINGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IM- PLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTA- BILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLIGATION OF EATON. THE CON- TENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BE- TWEEN THE PARTIES. As far as applicable mandatory law allows so, in no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability, or otherwise for any special, indirect, incidental, or consequential damage or loss whatsoev- er, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the infor- mation, recommendations, and descriptions contained herein. The information contained in this manual is subject to change without notice. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 5 1 General Devices of the series PowerXL™ DG1 are variable frequency drives for the supply of three phase in- duction motors. By default they are configured, that motors of the respective power class can be supplied without changing the settings. Many standard cases can be covered. There are some applications, which require an adaptation by changing parameters. In this Applica- tion Note the following aspects are covered: · Selection of the motor control mode · Adaptation to the connected motor · Slip compensation · Setting the V/f curve 2 Motor data Precondition for a proper operation is the right connection (star / delta) of the motor to the output ter- minals of the device. The rated voltage of the motor winding is decisive. Device Output Voltage Motor Connection DG1-32… 3 x 230 V 230 / 400 V Delta DG1-34… 3 x 400 V 230 / 400 V / 400 / 660 V Star Delta DG1-34… 3 x 400 V 230 / 400 V Delta Special case: 87 Hz-curve (see section 4.2) An adaptation to the connected motor can be done with the following parameters: · P1.6 Motor Nom Speed · P1.7 Motor PF · P1.8 Motor Nom Voltage · P1.9 Motor Nom Frequency The respective values can be taken from the name plate of the motor or from the data sheet of the motor manufacturer. They are used for the setting of the motor protection and define the V/f curve. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 6 2.1 Motor Nom Current Parameter P1.5 „Motor Nom Current" is set to the rated current Ie of the variable frequency drive by default. At the same time it is the set value for the thermal protection of the motor. In case the mo- tor has a nominal current different to the one of the VFD, P1.5 must be set accordingly to ensure motor protection. It must be pointed out, that the current value is set, which is assigned to the type of connection of the motor. In the example above it is 3,2 A at 230 V (Delta) respectively 1,9 A at 400 V (Star). Parameter Name Range Default P1.5 Motor Nom Current 0,1 · Ie … 2 · Ie Ie Ie = Rated current of the variable frequency drive All measures to protect the connected motor are described in the Application Note AP040176EN "Starting, stopping and operation". 2.2 Motor Nom Speed The setting of P1.6 „Motor Nom Speed" is necessary for three reasons: · to display the right speed value in all modes of operation · for calculation of the slip compensation in operation mode "Speed Control" (P8.1 = 1) · for calculations inside the motor model when operating in vector mode (P8.1 = 5 „Open Loop Speed Control" Please use the name plate value for setting P1.6. Parameter Name Range Default P1.6 Motor Nom Speed 300 … 20000 rpm 1750 rpm 2.3 Motor PF In vector mode (P8.1 = 5 „Open Loop Speed Control") the power factor (cos φ), which is specified on the motor's name plate, must be set. Parameter Name Range Default P1.7 Motor PF 0.3 … 1 0.85 2.4 Motor Nom Voltage Motor rated voltage (name plate) taking the connection (star / delta) into account. In exceptional cases, a different setting of P1-07 is necessary. See section 4.2 "87 Hz curve" Parameter Name Range Default P1.8 Motor Nom Voltage 180 … 690 V Ue Ue = Rated output voltage of the variable frequency drive, e.g. 230 V or 400 V depending on the device type 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 7 2.5 Motor Nom Frequency Rated frequency of the motor. By default this parameter is set to the mains frequency (50 Hz in Eu- rope, 60 Hz in USA) and doesn't need to be changed in the majority of cases. In case, motors with rated frequencies different from the mains frequency (e.g. 200 Hz for fast rotat- ing motors) or if the 87 Hz curve is used (see section 4.2), P1.9 has to be set accordingly. When changing the value of P1.9 the setting of P8.5 "Field Weakening Point" is set to the same value. If the application requires different values for P1.9 and P8.5, Motor Nom Frequency must be set first, before adopting the value for the field weakening point Parameter Name Range Default P1.9 Motor Nom Frequency 0.00 … 400.00 Hz 50 Hz 2.6 Motor Identification The motor identification MUST be performed in vector mode (P8.1 = 5 or 6) to gain the required pa- rameter values for an optimal performance of the motor. ATTENTION: The motor data (e.g. the resistance) change with the temperature. Therefore the motor identification run shall be performed with a warm motor. The kind of motor identification run is determined by the setting of P8.14 „Identification". The fol- lowing motor data are identified: · Motor Stator Resistance R1 (P8.50) · Motor Rotor Resistance R2 (P8.51) · Motor Leak Inductance X1 (P8.52) · Motor Mutual Inductance Xh (P8.53) · Motor Excitation Current (P8.54) P8.14 = 0: No Action No identification of the motor data will be performed. This is the setting during normal operation of the drive. P8.14 = 1: Identification Only Stator Resistor During the identification run only the stator resistance is identified. The other values remain un- changed. P8.14 = 2: Identification with Run The values for the parameters P8.50 ip to P8.54 are identified. The measurement is done with a run- ning motor. The motor must be unloaded (load decoupled, no gearbox …). P8.14 = 3: Identification No Run The values for the parameters P8.50 ip to P8.54 are identified. During the measurement the motor is standing still. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 8 How to perform a motor identification run: · Before starting a motor identification run, the motor data (parameters P1.5 up to P1.9) must be set. · Select the motor control mode P8.1 = "3 : Open Loop Speed Control". · Select in P8.14 „Identification", which kind of identification shall be performed (P8.14 = 1…3). · Remove any connection between the drive and a PC during identification run. · Apply START command · The identification of the motor data takes place automatically and is active for about 30 s re- spectively until the START signal will be removed. · On the keypad „Motor Identification" is shown. · The motor data are identified and assigned to the respective parameters. · In case an identification is not possible, the fault message "Motor ID Fault" (#57) is displayed. One reason could be that the rated power of the connected motor deviates too much from the one of the variable frequency drive. Alternatively the motor data can be set manually on the basis of information supplied by the motor manufacturer. · After a motor identification run, the START signal must be reapplied to start the motor. The motor doesn't start automatically, even when the START signal is still applied to the respec- tive terminal. · Parameter P8.14 "Identification" is reset to "0: No action" automatically as soon as the iden- tification run is finished. Parameter Name Range Default P8.14 Identification 0: No Action 1: Identification Only Resistor 2: Identification with Run 3: Identification No Run 0: No Action P8.50 Stator Resistor 0.001 … 65535 W 0.033 W P8.51 Rotor Resistor 0.001 … 65535 W 0.034 W P8.52 Leak Inductance 0.01 … 655.35 mH 0.12 mH P8.53 Mutual Inductance 0.1 … 6553.5 mH 3.4 mH P8.54 Excitation Current 0.1 … 7.4 A 0.1 A 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 9 3 Motor Control Mode Parameter P8.1 „Motor Control Mode" determines the way, how the motor is controlled (e.g. fre- quency or vector control). The information given inside the Application Note refer to the settings P8.1 = 0, 1 or 5. By default the variable frequency drive is configured for Frequency Control (P8.1 = 0), which is mainly used in simple applications. With speed control (P8.1 = 1 or 5) an improved speed accuracy and a better torque performance can be achieved. In this case the motor data must be set and with Open Loop Speed Control (P8.1 = 5) a motor identification run (P8.14, see section 2.6) is necessary. Parameter Name Range Default P8.1 Motor Control Mode 0: Frequency Control 1: Speed Control 5: Open Loop Speed Control 6: Open Loop Torque Control 0 3.1 Frequency Control (V/f) P8.1 = 0 The output frequency of the variable frequency drive is proportional to the reference, which is for example applied to an analog input. The ratio between the output voltage and the frequency is kept constant. This leads to a speed change when the load is changing, like with a single speed motor connected DOL to the mains. This control mode is preferred, when multiple motors are connected in parallel at the output of one single variable frequency drive especially in simple applications, where no special requirements concerning speed accuracy at variable load exist. 3.2 Speed Control P8.1 = 1 In this control mode the motor data must be set (P1.5 up to P1.9) The slip is the difference between a synchronous speed because of a rotating field and the actual speed of the motor. The name plate in section 2 shows a rated speed of 1410 rpm. It is a 4 pole mo- tor with a synchronous speed of 1500 rpm. Between no load and rated load there is a slip of 90 rpm. Running the motor with a variable frequency drive, one wants to prevent the speed variance by compensating the slip. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 10 with slip compensation without slip compensation With slip compensation: at load increase j voltage and frequency are increased accordingly k. The speed n1 remains constant. At load decrease voltage and frequency are reduced. Without slip compensation: with load j the speed drops from n1 to n2 k, when unloading the speed increases again. 3.3 Open Loop Speed Control P8.1 = 5 Open loop means, that a feedback of the motor speed to the variable frequency drive, e.g. by using an encoder, is not required. The speed information used in the control algorithm is the result of a calculation by the motor model. To ensure an optimal performance, the motor data (parameters P1.5 up to P1.9) must be set and a motor identification run must be performed (see section 2.6). Speed accuracy and torque performance are improved compared to the motor control mode "Speed Con- trol" described in section 3.2. Note: When multiple motors are connected in parallel to one single variable frequency drive, this motor control mode may not be used! 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 11 4 V/f curve The V/f curve determines the magnetization of the motor and therefore the torque behavior signifi- cantly. In addition the energy efficiency of the complete system can be impacted. As described in section 3, multiple motor control modes exist. Common to all of them is, that the field weakening point (FWP) and the maximum frequency must be defined. In case of open loop speed control (P8.1 = 5), the variable frequency drive calculates the necessary settings on the basis of this information and the determined motor data. In case of frequency control (P8.1 = 0) or speed control with slip compensation (P8.1 = 1) it is possible to modify the V/f curve to improve the torque behavior (see section 4.1). · P1.2 „Max Frequency" maximum frequency for the application. This frequency may be above the „Motor Nom Fre- quency" (P1.9). · P8.5 „Field Weakening Point" This parameter defines the frequency, at which the maximum output voltage, defined with P8.6, is reached. · P8.6 „Voltage at FWP" Maximum voltage of the variable frequency drive in percent of the Motor Nom Voltage (P1.8). This voltage is reached at the field weakening point (FWP) defined with P8.5. Note: At a change of parameter P1.9 „Motor Nom Frequency" P8.5 is automatically set to the same frequency value. In applications, where the frequency at FWP is different to the Motor Nom Fre- quency, P1.9 must be set first, before setting P8.5. The same is true for the voltage. Here P1.8 „Mo- tor Nom Voltage" must be set before P8.6 "Voltage at FWP". Parameter Name Range Default P1.2 Max Frequency P1.1 … 400 Hz 50.0 Hz P8.5 Field Weakening Point 8.0 Hz … P1.2 P1.9 P8.6 Voltage at FWP 10 … 200 % – P1.8 P1.8 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 12 4.1 Optimizing the V/f curve at Frequency Control and Speed Control The V/f curve shown in section 4 is idealized (P8.4 = 0 "Linear") and sufficient for many applications. There are two cases, where the shape of the V/f curve should be adopted: · where a higher starting torque is required, respectively where the motor has to run at lower speed stationary · in pump and fan applications, where the motor losses shall be reduced by field weakening under part load conditions. The different shapes of the V/f curve can be selected with P8.4 "V/Hz Ratio". · P8.4 = 0 „Linear" Voltage and frequency change linearly from zero up to the field weakening point (FWP). · P8.4 = 1 „Squared" Voltage and frequency change squared from zero up to the field weakening point (FWP). See also section 4.1.2. · P8.4 = 2 „Programmable" The shape of the curve can be configured, see also section 4.1.1- · P8.4 = 3 „Linear + Flux Optimization" The shape of the V/f curve is adapted to the load conditions automatically, see also section 4.1.2. Parameter Name Range Default P8.4 V/Hz Ratio 0: Linear 1: Squared 2: Programmable 3: Linear + Flux Optimization 0: Linear 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 13 4.1.1 Improving the torque behavior When operating with lower speeds, the voltage drop inside the motor becomes particularly noticea- ble, which leads to a reduced speed, unbalanced run and in extreme cases to a standstill of the motor with current flow at the same time. This effect can be reduced by increasing the output voltage in the lower speed range. P8.3 "V/Hz Optimization" determines, in which way this will be achieved: · P8.3 = 1 „Enabled" The voltage is increased automatically. The value depends on the motor rating and the values are based on experience. Setting: o Set motor data in parameter group 1 (P1.5 up to P1.9) o P8.3 = 1: Enabled · P8.3 = 0 „Disabled" The shape of the V/f curve can be configured manually. In this case P8.4 „V/Hz Ratio" has to be set to „2: Programmable". · P8.7 „V/Hz Mid Frequency" · P8.8 „V/Hz Mid Voltage" · P8.9 „Zero Frequency Voltage" The V/f curve is divided into two sections. It starts at zero frequency with P8.9 „Zero Frequency Voltage", proceeding linearly to a point defined by P8.7 "V/Hz Mid Frequency" for the frequency and by P8.8 "V/Hz Mid Voltage" for the voltage. From there to the field weakening point (FWP). With this measure it is possible to increase the voltage in the lower speed range above aver- age to compensate the voltage drop inside the motor and to improve the torque behavior. Beside other cases this measure is used, when a drive is operated in the lower speed range station- ary. It has to be noted, that the cooling of the motor is usually realized by a fan, which is mounted on the motor's shaft and whose cooling effect is reduced correspondingly. When a certain torque is required in this range, it must be ensured, that the motor will not be overheated. Eventually a sepa- rately driven fan must be used. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 14 When setting the parameters, the motor must initially be operated unloaded with linear V/f curve. It is presumed, that the motor data (P1.5 up to P1.9) are set already and that the general settings for the V/f curve (see section 4) are completed. · P8.4 „V/Hz Ratio" = 0: Linear · Run the motor with 2/3 of its rated speed. · Read the motor current on the keypad or in the configuration software inControl (M4). Be- cause of the unloaded motor the actual current corresponds approximately to the excitation current. · Remove START signal · Set P8.54 „Excitation Current" to the value measured before. It is required for internal calcu- lations. · P8.4 „V/Hz Ratio" = 2: Programmable · During the following settings P1.1 "Min Frequency" must be set to zero, even when the ap- plication requires higher values for the minimal frequency during normal operation. When the V/f settings are completed, P1.1 can be set back to the value, which is required by the application. · Frequency reference = 0, start variable frequency drive · Increase the value of P8.9 "Zero Frequency Voltage", until the current is as high as measured before. · Stop drive · Set P8.7 and P8.8 to the required values. The setting is application dependent. Additional to the settings here it is possible to set the motor control mode (P8.1) to "1: Speed Control" and/or to enable the "V/Hz Optimization" with P8.3. In general good results can be achieved by using the following rule of thumb: o P8.8 = 1,4 – P8.9 o P8.7 = P8,5 – (P8.8 : P8.6) Parameter Name Range Default P8.3 V/Hz Optimization 0: Disabled 1: Enabled 0: Disabled P8.7 V/Hz Mid Frequency 0 Hz … P8.5 0 Hz P8.8 V/Hz Mid Voltage P8.9 … P8.6 P8.9 Zero Frequency Voltage 0 % … 40 % P8.6 0 % P8.54 Excitation Current Depends on drive rating 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 15 4.1.2 Increasing energy efficiency Objective is to reduce the losses inside the motor to increase the overall system efficiency. Because of the voltage reduction the field of the motor is weakened, which leads to a reduction of the reac- tive current, while the active one is increasing at the same time, but not as much as the reactive cur- rent decreases. This leads to a decrease of the overall motor current. This principle is only applicable, when the application doesn't require full torque in the complete speed range. The device series DG1 has two possibilities to achieve this: · P8.4 „V/Hz Ratio" = 1: Squared with this setting the voltage increases squared with the frequency, until it reaches it maxi- mum at the FWP, see also drawing in section 4.1.1 · P8.4 „V/Hz Ratio" = 3: Linear + Flux Optimization In principle the V/Hz curve is linear. When the drive operates under part load conditions for a certain time (approximately 1 minute), the voltage is automatically decreased by some Volts. The procedure is repeated until the current is at its minimum. This leads to less losses inside the motor and to a noise reduction. In case a higher torque is required the drive returns to its linear V/f curve and the process starts again. This kind of energy optimization makes sense, when different torque can be required at the same speed. This principle is only applicable to drives without short term speed changes, but with constant speed for a certain time. 4.2 87 Hz curve In the majority of cases standard asynchronous motors are used up to their rated frequency. The maximum output frequency of the variable frequency drive is 50 Hz. The power of the motor can be increased by √3, by increasing the frequency from 50 Hz to 87 Hz (50 Hz · √3), keeping the flux (mag- netizing current) constant at the same time. Conditions at a 400 V mains · The motor is wounded for 230/400 V (not 400/690 V) · The windings are connected in delta. · The variable frequency drive has a maximum output voltage of 400 V and a maximum frequency of 87 Hz. This results in 50 Hz at 230 V. · The variable frequency drive is selected for a current which is the rated current of the motor at 230 V. Parameters · P1.8 = 400 V · P1.9 = 87 Hz (with 50 Hz on the name plate) 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 16 Example for selection: Motor data · 230 / 400 V · 3,2 / 1,9 A · 0,75 kW · 1410 min-1 · 50 Hz Selection · Device rated for 400 V, but for the current which is assigned to 230 V (here: 3,2 A) à DG1-343D3FB-C21C. · The power of the motor results in 0,75 kW · √3 = 1,3 kW (rated torque at √3 times rated speed). · The synchronous speed of the motor is 1500 rpm · √3 = 2598 rpm · The expected speed at rated load is 2598 rpm – 90 rpm = 2508 rpm Remark: 90 rpm corresponds to the slip speed (1500 min-1 – 1410 min-1) MTL5500 range Isolating interface units June 2024 INM 5500 Rev 18 Instruction manual MTL intrinsic safety solutions INM 5500 Rev 18ii DECLARATION OF CONFORMITY A printed version of the Declaration of Conformity has been provided separately within the original shipment of goods. However, you can find a copy of the latest version at: http://www.mtl-inst.com/certificates INM 5500 Rev 18iii CONTENTS DECLARATION OF CONFORMITY ii IMPORTANT NOTE v ATEX/UKCA/IECEX SAFETY INSTRUCTIONS vi/vii 1 INTRODUCTION 1 2 DESCRIPTION 1 3 INSTALLATION 2 3 1 Modules – pre-installation 3 3 2 Installing columns of isolators 4 4 ACCESSORIES 6 4 1 MTL5500 power bus - Installation and use 6 4 2 MPA5500 AC power adaptor 7 4 3 Earth rail and tagging accessories 8 5 DX ENCLOSURES 12 5 1 Environmental conditions 12 5 2 Mounting 16 5 3 Accessories in enclosures 17 5 4 IS warning label 17 6 UNIT DESCRIPTIONS, SETTING-UP AND CONNECTIONS 18 6 1 Digital Input modules 19 6.1.1 Phase reversal . . . . 19 6.1.2 Line-Fault Detection (LFD) . . . . 19 6.1.3 MTL5501-SR - Fail-safe Switch/Proximity detector interface . . . . 20 6.1.4 MTL5510 & MTL5510B - Switch/Proximity detector interface . . . . 21 6.1.5 MTL5511 - Switch/Proximity detector interface . . . . 25 6.1.6 MTL5513 - Switch/Proximity detector interface . . . . 26 6.1.7 MTL5514/ MTL5514D/MTL5514-T - Switch/Proximity detector interface . . . . 27 6.1.8 MTL5516C - Switch/Proximity detector interface . . . . 28 6.1.9 MTL5517 - Switch/Proximity detector interface . . . . 29 6 2 Digital Output modules 30 6.2.1 MTL5521/MTL5521-T - Solenoid Alarm driver . . . . 30 6.2.2 MTL5522 - Solenoid Alarm driver . . . . 31 6.2.3 MTL5523 - Solenoid Alarm driver . . . . 32 6.2.4 MTL5523V/MTL5523VL - Solenoid Alarm driver . . . . 33 6.2.5 MTL5524 - Solenoid Alarm driver . . . . 34 6.2.6 MTL5525 - Solenoid Alarm driver . . . . 35 6.2.7 MTL5526 - Switch Operated Relay . . . . 36 6 3 Pulse, Vibration and Foundation Fieldbus modules 37 6.3.1 MTL5531 - Vibration Transducer Interface . . . . 37 6.3.2 MTL5532 - Pulse Isolator . . . . 38 6.3.3 MTL5533 - Vibration Transducer Interface . . . . 40 6.3.4 MTL5553- Isolator/power supply for 31.25kbit/s fieldbuses . . . . 41 6 4 Analogue Input modules 42 6.4.1 MTL5541/MTL5541S/MTL5541S-T - Repeater Power Supply . . . . 42 6.4.2 MTL5541A/MTL5541AS - Repeater Power Supply . . . . 43 6.4.3 MTL5544/MTL5544S - Repeater Power Supply . . . . 44 6.4.4 MTL5544A/MTL5544AS - Current Repeater . . . . 45 6.4.5 MTL5544D - Repeater Power Supply . . . . 46 (continued on next page) INM 5500 Rev 18iv 6 5 Analogue Output modules 47 6.5.1 MTL5546/MTL5546Y/MTL5546Y-T - Isolating Driver . . . . 47 6.5.2 MTL5549/MTL5549Y - Isolating Driver . . . . 48 6 6 Fire and Smoke Interface modules 49 6.6.1 MTL5561 - Fire and Smoke Detector Interface . . . . 49 6 7 Temperature Input modules 50 6.7.1 MTL5573 - Temperature Converter . . . . 51 6.7.2 MTL5575 - Temperature Converter . . . . 52 6.7.3 MTL5576-RTD - Temperature Converter . . . . 53 6.7.4 MTL5576-THC - Temperature Converter . . . . 54 6.7.5 MTL5581 - mV/Thermocouple Isolator . . . . 55 6.7.6 MTL5582/MTL5582B - mV/Resistance Isolator . . . . 56 6 8 General modules 57 6.8.1 MTL5599 - Dummy Isolator . . . . 57 6.8.2 PSG60E24RM Power Supply . . . . 58 6 9 PCS45/PCL45USB configurator for MTL temperature converters 59 7 FAULT FINDING AND ROUTINE MAINTENANCE 59 7 1 Maintenance precautions 59 7 2 Fault finding 59 7 3 Routine maintenance 59 8 BENCH TESTING MODULES 60 8 1 Digital Input (DI) modules 60 8 2 Digital Output (DO) modules 61 8 3 Analogue Input (AI) Modules 62 8 4 Analogue Output (AO) Modules 65 8 5 Testing the functioning of other modules 65 9 APPLICATIONS INVOLVING ZONE 2 AND/OR ZONE 22 HAZARDOUS AREAS 66 9 1 Enclosure 67 10 APPENDIX 1 68 10 1 MTL5000 68 10 2 MTL5018AC - Switch/proximity detector 69 10 3 MTL5051 serial data comms isolator 71 10 4 MTL5314 trip

amplifier for 2– or 3– wire transmitters 74 11 APPENDIX 2 77 11 1 Table A - Safety descriptions 77 11 2 Table B - Maximum cable parameters - IIC gas group 78 INM 5500 Rev 18v IMPORTANT NOTE WARNING This manual has content describing the use and installation of safety equipment This equipment must be installed, operated and maintained only by trained competent personnel and in accordance with all appropriate international, national and local standard codes of practice and site regulations for intrinsically safe apparatus and in accordance with the instructions contained here WARNING This equipment must be used in accordance with the instructions in this manual otherwise the protection provided by the equipment may be impaired ATEX If the country of installation is governed by the Essential Health and Safety Requirements (Annex II) of the EU Directive 2014/34/EU [the ATEX Directive - safety of apparatus] then consult the ATEX safety instructions for safe use in this manual before installation. Note: Refer to the website for multiple language safety instructions. ELECTRICAL PARAMETERS Refer to the certification documentation for the electrical rating of these products. CERTIFICATION DOCUMENTATION Our website http://www.mtl-inst.com contains product documentation regarding intrinsic safety certification for many locations around the world. Consult this data for information relevant to your local certifying authority. FUNCTIONAL SAFETY If the MTL5500 range of products are to be used in functional safety applications check that each module has been assessed for that service and refer to the Safety Manual for details. REPAIR MTL5500 range of products MUST NOT be repaired. Faulty or damaged products must be replaced with an equivalent certified product. Symbols used on the product and in this manual CAUTION - Read the instructions CAUTION - Hot surface INM 5500 Rev 18vi ATEX/UKCA/IECEx SAFETY INSTRUCTIONS The following information is in accordance with the Essential Health and Safety Requirements (Annex II) of the EU Directive 2014/34/EU [the ATEX Directive - safety of apparatus], and Schedule 1 of the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 (UK S.I. 2016/1107) and is provided for those locations where the ATEX Directive or UKCA regulations are applicable. General a) This equipment must only be installed, operated and maintained by competent personnel. Such personnel shall have undergone training, which included instruction on the various types of protection and installation practices, the relevant rules and regulations, and on the general principles of area classification. Appropriate refresher training shall be given on a regular basis. [See clause 4.2 of IEC/EN 60079-17]. b) This equipment has been designed to provide protection against all the relevant additional hazards referred to in Annex II of the ATEX directive (such as clause 1.2.7) or Schedule 1 of the UK regulation (such as clause 13). c) This equipment has been designed to meet the requirements of IEC/EN 60079-0, IEC/EN 60079-7, IEC/EN 60079-11 and IEC/EN 60079-15. Installation a) The installation must comply with the appropriate European, national and local regulations, which may include reference to the IEC code of practice IEC/EN 60079-14. In addition, particular industries or end users may have specific requirements relating to the safety of their installations and these requirements should also be met. For the EU, Directive 1999/92/EC [the ATEX Directive - safety of installations} is also applicable. For the UK, the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) is also applicable. b) This apparatus is an associated electrical apparatus and is normally mounted in a non- hazardous [safe] area. The equipment may be installed in a Zone 2 location providing that equipment is covered by a suitable certificate and the relevant installation conditions are met. Refer to "Special Conditions for Safe Use – Zone 2 mounting" below. c) Unless already protected by design, this equipment must be protected by a suitable enclosure against: i) mechanical and thermal stresses in excess of those noted in the certification documentation and the product specification ii) aggressive substances, excessive dust, moisture and other contaminants. Read also the Special Conditions for Safe Use (below) for any additional or more specific information. Special Conditions of Safe Use for Zone 2 applications a) When used in Zone 2, the equipment must be installed in an area of Pollution Degree 2 or better, as defined in IEC 60664-1, and in an enclosure or an environment that provides a degree of protection of at least IP54 and meets the relevant material and environmental requirements of IEC/EN 60079- 0, and IEC/EN 60079-7 or IEC/EN 60079-15 as appropriate. b) The equipment must not be inserted or removed unless either: i) the area in which the equipment is installed is known to be non-hazardous or ii) the circuit to which it is connected has been de-energised. c) The 24V supply for this equipment must be derived from a regulated power supply complying with the requirements of European Community Directives. d) For MTL5511, MTL5514, MTL5514D, MTL5516C, MTL5517, MTL5526 & MTL5532 only: Relay contacts may switch up to 35V, 2A and 100VA. For MTL5575: Relay contacts may switch up to 35V, 250mA. e) For MTL5573: Maximum Input/Output parameters – see certificate f) For MTL5553: The ambient temperature stated on the certificate refers to the temperature within the enclosure into which it must be installed in accordance with condition number 1). It is the responsibility of the installer to ensure that there is adequate isolation between the MTL 5553 Isolator and the frame of the supplementary enclosure. The equipment must be capable of withstanding the 500V dielectric strength test in accordance with clause 6.1 of IEC 60079-7 between the equipment and the supplementary enclosure. This must be taken into account during installation. The maximum values for the intrinsically safe circuits have to be taken from the IECEx Certificate of Conformity IECEx BAS 18.0060. g) Special Conditions will vary on individual certificates. INM 5500 Rev 18vii Inspection and maintenance a) Inspection and maintenance should be carried out in accordance with European, national and local regulations which may refer to the standard IEC/EN 60079-17. In addition specific industries or end users may have specific requirements which should also be met. b) Access to the internal circuitry must not be made during operation. Repair a) This product cannot be repaired by the user and must be replaced with an equivalent certified product. Marking Each device is marked in compliance with the EU Directive and UK regulation, and CE and UKCA marked accordingly. Example label showing markings: INM 5500 Rev 18viii This page is left intentionally blank INM 5500 Rev 181 1 INTRODUCTION This instruction manual describes the procedures for installing, connecting, checking and maintaining MTL5500 range of isolating interfaces and accessories. The MTL5500 products provide a DIN-rail mounted, intrinsically safe interface to hazardous areas of a process plant. The individual sections of this manual cover the following topics • Section 2 describes the range • Section 3 specifies precautions both before and during installation • Section 4 describes mounting accessories and the power adaptor • Section 5 discusses the DX range of enclosures • Section 6 provides relevant technical data • Section 7 outlines fault-finding and maintenance procedures • Section 8 describes bench test procedure • Section 9 provides hazardous-area application information • Section 10 provides MTL5000 products information • Section 11 provides safety parameter information 2 DESCRIPTION MTL5500 range of isolators provide intrinsically safe (IS) communication and signal conditioning for a wide range of hazardous-area devices. Total AC and DC isolation exists between input, output and power supply on separately powered units, and between input and output on loop-powered units. No IS earth is required. DIN-rail mounting and plug-in signal and power connectors simplify installation and maintenance. Units are powered from a 20 to 35V DC supply, or, in some cases, from the signal itself. Our latest generation of IS interfaces utilises an innovative "One-Core" technology to ensure the highest quality and availability while maintaining maximum flexibility at lowest cost. Incorporating advanced circuit design, a common set of components and innovative isolating transformer construction, they achieve a significant reduction in power consumption while increasing channel packing densities. The compact, 16mm wide design reduces weight and gives exceptionally high packing density. They build on the proven success of the MTL2000, 3000, 4000 and 5000 ranges to bring the benefits of new developments in galvanic isolation without compromising the reliability of the designs from which they have evolved. The backplane mounting MTL4500 range is designed with system vendors in mind for "project- focussed" applications such as Distributed Control System (DCS), Emergency Shutdown Systems (ESD) and Fire and Gas monitoring (F&G). The DIN-rail mounting MTL5500 range meets the needs of the IS interface market for "application focussed" projects, ranging from single instrument loops, through to fully equipped cabinets, across all industries where hazardous areas exist. Both new ranges have been designed for compatibility with earlier models. The MTL4500 range provides plug-replacements for earlier MTL4000 range of units, while the MTL5500 models can easily replace MTL5000 range of units. Each offer the latest in modern technology and efficiency without compromise. In addition to their use in IS circuits, specific models within the MTL4500 and MTL5500 ranges have been assessed and approved for use in Functional Safety applications. These have been verified under the certified Functional Safety Management (FSM) programme implemented by us. INM 5500 Rev 182 The table below lists the modules in the MTL5500 range. Refer also to the individual MTL5500 range of data sheets. Digital Input Channels Function MTL5501-SR 1 fail-safe, solid-state output + LFD alarm MTL5510 4 switch/prox input, solid-state output MTL5510B 4 multi-function, switch/prox input, solid-state output MTL5511 1 switch/prox input, c/o relay output MTL5513 2 switch/prox input, solid-state output MTL5514/5514-T 1 switch/prox input, relay + LFD MTL5514D 1 switch/prox input, dual relay output MTL5516C 2 switch/prox input, relay + LFD outputs MTL5517 2 switch/prox input, c/o relay + LFD outputs Digital Output MTL5521/5521-T 1 loop-powered solenoid driver MTL5522 1 loop-powered solenoid driver, IIB MTL5523 1 solenoid driver with LFD MTL5523V 1 solenoid driver with LFD + voltage control, IIC MTL5523VL 1 solenoid driver with LFD + voltage control, IIC MTL5524 1 switch operated solenoid driver MTL5525 1 switch operated solenoid driver, low power MTL5526 2 switch operated relay Pulse, Vibration and Foundation Fieldbus modules MTL5531 1 vibration probe interface MTL5532 1 pulse isolator, digital or analogue output MTL5533 2 vibration probe interface MTL5553 1 isolator/power supply for 31.25kbits/s fieldbuses Analogue Input MTL5541/MTL5541-T 1 2/3 wire transmitter repeater MTL5541A 1 transmitter repeater, passive input MTL5541AS 1 transmitter repeater, passive input, current sink MTL5541S/5541S-T 1 2/3 wire transmitter repeater, current sink MTL5544 2 2/3 wire transmitter repeater MTL5544A 2 transmitter repeater, passive input MTL5544AS 2 transmitter repeater, passive input, current sink MTL5544S 2 2/3 wire transmitter repeater, current sink MTL5544D 1 2/3 wire transmitter repeater, dual output Analogue Output MTL5546 1 4-20mA smart isolating driver + LFD MTL5546Y/5546Y-T 1 4-20mA smart isolating driver + oc LFD MTL5549 2 4-20mA smart isolating driver + LFD MTL5549Y 2 4-20mA smart isolating driver + oc LFD Fire and Smoke MTL5561 2 loop-powered for fire & smoke detectors Temperature Input MTL5573 1 temperature converter, THC or RTD MTL5575 1 temperature converter, THC or RTD MTL5576-RTD 2 temperature converter, RTD MTL5576-THC 2 temperature converter, THC MTL5581 1 mV/thermocouple isolator for low level signals MTL5582/5582B 1 mV/resistance isolator to repeat RTD signals General MTL5599 1 dummy module INM 5500 Rev 183 3 INSTALLATION Important • Make sure that all installation work is carried out in accordance with all relevant local standards, codes of practice and site regulations. • When planning the installation of MTL5500 range of isolators it is essential to make sure that intrinsically safe and non-intrinsically safe wiring is segregated, and that units are installed as required by a nationally accepted authority or as described in EN 60079-14, ISA RP 12.6 or DIN VDE-165. • External power supply shall contain double isolation from hazardous voltages or that unit shall be supplied by Limited Power Circuit per UL/IEC 60950 or Limited Energy Circuit per UL/IEC 61010 or Class ll Power Supply per NEC. • Environmental conditions: indoor use, altitude (up to 2000m) and humidity less than 95% non condensing. • Check that the hazardous-area equipment complies with the descriptive system document. • If in doubt, refer to the certificate/catalogue for clarification of any aspects of intrinsic safety or contact Eaton's MTL product line or your local representative for assistance. • Make sure the correct hazardous-area connector (field-wiring plug) is plugged into the corresponding isolator. It is recommended that the connector is identified by the same tag number as the matching isolator. Figure 3 1: Dimensions of MTL5500 package Mount all MTL5500 range of isolators on low-profile (7mm) or high-profile (15mm) type T35 (top-hat) DIN-rail to EN50022, BS5584, DIN46277. This is available from Eaton, in 1 metre lengths (THR2 - DIN rail). Install isolators within the safe area unless they are enclosed in approved flameproof, pressurised or purged enclosures and ensure that the local environment is clean and free of dirt and dust. Note the ambient temperature considerations of section 3.1.4. It is recommended that, in normal practice, the DIN rail should be earthed/grounded to ensure the safety of personnel in the event of a.c. mains (line) power being applied accidentally to the rail. SAFEHAZ 104.8 109.8 123.6 118.8 Top of DIN rail PWR OPB OP A OPD OPC FLT Optional TH5000 tag holder for individual isolator identification. Accepts tag label 25 x 12.5 ±0.5mm, 0.2mm thick 15.8 +/– 0.2 INM 5500 Rev 184 3 1 Modules – pre-installation 3 1 1 Switch settings for operating conditions Some modules have operating conditions, such as Line-Fault Detection (LFD), Phase Reversal, etc., that can be established by the setting of switches on the unit. The subminiature switches are accessible through an aperture on the side of the module (see Figure 3.2) and can be set in the required positions with, for example, the blade of a small screwdriver. The switch setting options are always indicated on the side label of the module, but the user may also consult the individual module information in Section 6 of this manual for details. Figure 3 2: Location of switches 3 1 2 Relay outputs Reactive loads on all units with relays should be adequately suppressed. To achieve maximum contact life on all mechanical output relays, the load should not be less than 50mW, e.g. 10mA at ≥ 5V DC. 3 1 3 Ambient temperature considerations Ambient temperature limits for unenclosed MTL5500 range of isolators are from –20°C to +60°C with units close-packed and modules with the -T suffix have an extended temperature rating of +65°C, unless otherwise specified. 3 2 Installing columns of isolators On new installations, if isolators are mounted in several rows or columns, mount alternate rows or columns so that units face in opposite directions. This allows safe- and hazardous-area wiring looms to be shared. See Figure 3.1 for isolator dimensions. 3 2 1 Mounting isolators on DIN rail Figure 3 3: DIN rail mounting and removal of isolators Clip an isolator onto the DIN rail as shown in Figure 3.3, with the blue signal plugs facing towards the hazardous-area. To remove an isolator from the rail, insert a screwdriver blade (2.5 - 5.0mm diam.) into the clip as shown. This will release the clip so that the isolator may be pivoted off the rail - there is no need to lever the clip. Allow a maximum mounting pitch of 16.2mm for each unit. OFF position ON position 1 2 3 4 Mounting Removal INM 5500 Rev 185 3 2 2 Wiring up isolators Each unit is supplied with the appropriate number and type of safe- and hazardous-area connectors (see Figure 3.4), as dictated by the terminals used and the type of power supply. Figure 3 4: Removable power and signal plugs Note: Earth Leakage Detection requires the use of hazardous area connector type HAZ1-3, which may need to be ordered separately. See datasheet for ordering information. Loop-powered devices do not require power connectors. Depending on the installation, it may be easier to wire up isolators with power and signal plugs either in place or removed. Either way, allow sufficient free cable to permit plugs to be removed easily for future maintenance and/or replacement purposes. See Section 6 for instructions on wiring individual modules. 3 2 2 1 Signal and power conductors Removable signal and power plugs are fitted with screw clamp terminals. Note that the conductors should be between 14 and 24 AWG (1.6 and 0.5mm diam.) in size. Signal plugs, located on top of the modules, are mechanically keyed to fit in only one position. They are coloured grey, for safe-area connections, and blue, for hazardous-area connections. For externally powered units, a power plug slots into the socket at terminals 13 and 14 on the safe-area side of each module. The socket is coloured black if the unit is dc powered. Power plugs are coloured grey, for plugging into the black sockets of dc powered units. 3 2 2 2 Making connections a) Trim back the insulation of conductors by 12mm. b) Check the terminal assignments shown in section 6 or on the side label of the unit. c) Insert conductors according to the terminal assignments and tighten screws. If the wires are to be fitted with crimp ferrules, the following is a list of those recommended with required trim lengths for each: Plug type Entry Wire size (mm2) Metal tube length (mm) Trim length Recommended ferrules Signal Single 0.75 12 14 Weidmuller 902591 Signal Single 1.0 12 14 Cembre PKC112 Signal Single 1.0 12 14 Phoenix Contact AI 1-12 RD (3200674) Signal Single 1.5 12 14 Cembre PKE1518† Signal Single 2.5 12 14 Cembre PKE2518† Power Twin 2x0.75 10 12 Cembre PKET7510 Power Twin 2x0.75 10 12 AMP (non-preferred) 966144-5 Power Twin 2x1.0 10 12 Phoenix Contact AI-TWIN 2X 1-10 RD Power Single 0.75 10 12 AMP 966067-0 Power Single 1.0 10 12 Phoenix Contact AI 1-10 RD TABLE 3 1: Crimp Ferule Options † These ferrules with 18mm length metal tubes should be cut to 12mm after crimping Note: Smaller section wire than that stated can often be successfully used if the crimping is good. Crimp tool: Phoenix Contact Crimpfox UD6 part number 1204436 Power Plugs Grey: dc supplies (PWR5000) Signal Plugs Grey: safe-area side Blue: hazardous-area side 12mm trim length with ferrule see table below INM 5500 Rev 186 3 2 2 3 Finishing Wire up individual isolators in accordance with wiring schedules. Daisy-chain power supply connections between individual power plugs or use the power bus (see section 4.1). Segregate hazardous- and safe-area wiring into separate trunking or looms wherever possible to avoid errors and maintain a tidy installation. Use an MTL5599 dummy isolator to provide termination and earthing for unused cores from the hazardous area. 4 ACCESSORIES 4 1 MTL5500 power bus - Installation and use 4 1 1 MTL5500 range power bus A power bus kit enables power supply terminals (13 and 14) of up to 32 installed MTL5500 range of units to be linked to a standard 24V power supply. The bus consists of a chain of power plugs and different lengths are available to suit various numbers of modules as follows. Number of modules Kit ID code (contains grey power plugs for 24V dc supply) 1 to 8 PB-8T 9 to 16 PB-16T 17 to 24 PB-24T 25 to 32 PB-32T Table 4 1: Power bus kit options 4 1 2 Installation 1. Check to make sure the bus length is correct for the number of modules involved. 2. If the number of modules is less than the maximum number the chain will support, cut off the surplus power plugs at the tail end of the chain - leaving sufficient cable to attach further power plugs if it becomes necessary later. 3. Insert power plugs into the power terminals on the safe- area side of each module in sequence. 4. Connect the power supply source to the tail end of the chain (using the insulation displacement connectors [Scotchloks] provided if required). Notes: 1. To avoid excessive voltage drop or over-current, DO NOT connect power buses in . 2. Surplus sections can be used (and, if required) connected together provided the cut ends are safely terminated and/or connected together. Use single ferrules with a crimp tool or insulation displacement connectors (Scotchloks). Suitable ferrules and connectors are provided with the kits. Figure 4 1: Power bus wiring, joining and terminating – + Optional insulation displacement connectors x2 INM 5500 Rev 187 4 2 MPA5500 AC power adaptor When only one or two MTL5500 modules are required for a particular application, it may be desirable to power the units from the AC mains supply directly, rather than use a separate DC supply unit. The MPA5500 is an adaptor that plugs into the DC power socket on the side edge of an MTL5500 module and clips securely onto the module housing. Its 25V DC power output is sufficient to supply a single module and can be connected to any normal ac power source. Figure 4 2: MPA5500 AC power adaptor To fit the adaptor, locate the tongue of the adaptor into the top slot on the side of the MTL5500 module and press the adaptor until it fits closely to the body of the module, as shown. Use double-insulated AC power cable with conductor parameters of 0.2–1.5mm2, or 0.25– 1.5mm2 if using ferrules. Strip the outer insulation by no more than 30mm, then strip the inner conductors by 8mm. Insert the cables appropriately in the cage-clamp connectors marked 'L' and 'N'. The incoming AC power must have some form of power disconnection device, such as a switch or circuit breaker; a coupler that can be disconnected without the use of a tool; or a separable plug, without a locking device, to mate with an adjacent socket outlet. In addition, some form of cable anchorage must be used to relieve the cable conductors from strain, including twisting, where they connect to the adaptor, and which will also protect the insulation of the cable from abrasion. WARNING This adaptor is not suitable for use with MTL5000 range of modules. Direction of removal of MPA5500 Area required for removal of MPA5500 11 20 15.8 118.8 133 AC inputs Top of DIN rail INM 5500 Rev 188 4 3 Earth rail and tagging accessories This section explains how to specify and assemble earth rail and tagging strip accessories for the MTL5500 range. The accessories consist of mounting brackets, earth rails, tagging strips and associated parts. They provide facilities for earthing, terminating cable screens and tagging (identifying) the positions of individual units. 4 3 1 Parts list IMB57 Insulating mounting block (Figures 4 3, 4 4 & 4 5) One required at each end of a tagging strip/earth rail. Suitable for low-profile (7.5mm) and high- profile (15mm) symmetrical DIN rail. ERB57S Earth-rail bracket, straight (figure 4 3, 4 4 & 4 9) Nickel-plated bus bar; supplied with two push fasteners, one earth-rail clamp (14mm, 35mm2) and one earth cable clamp (10mm, 16mm2). Note: ERB57S is the preferred choice of earth-rail bracket. It is usually fitted in the upper slot on insulating mounting block IMB57. Where the earth rail is required to be positioned at a lower height and to allow access to the IMB57 mounting screws, the straight earth-rail bracket ERB57S can be inserted in the lower slot, but only after insulating mounting blocks IMB57 are clamped to the DIN rail. This may not be possible if, for example, trunking is fitted. In this case, fit offset earth-rail bracket ERB570 (see figure 4.4 & 4.10) in the upper slot: the mounting blocks can then be fitted in a restricted space with this bracket already fitted. ERB570 Earth-rail bracket, offset (figure 4 9) Nickel-plated bus bar; supplied with two push fasteners, one earth-rail clamp (14mm, 35mm2) and one earth cable clamp (10mm, 16mm2). ERL7 Earth rail, 1m length (figure 4 9) Nickel-plated bus bar; may be cut to length. TAG57 Tagging strip, 1m length (figure 4 3, 4 4 & 4 6) Cut to size. Supplied with tagging strip label. TGL57 Tagging strip labels, set of 10 x 0 5m (figure 4 3 & 4 4) Spares replacement, for use with TAG57 tagging strip. MS010 DIN rail module spacer, 10mm, pack of 5 (figure 4 7) Grey spacer; Used to provide 10mm air-circulation space between modules, if necessary. ETM7 Earth terminal, bag of 50 (figure 4 8) For terminating cable screens and 0V returns on the ERL7 earth rail. For cables ≥ 4mm2. TH5000 Tag holder Spares replacement. Connectors (Figure 4 5) Spares replacement: HAZ1-3, HAZ4-6, HAZ-CJC, PWR5000, SAF7-9, SAF10-12 (SAF1-3 and SAF4-6 grey connectors, also available for use in safe-area applications). 4 3 2 Assembly 4 3 2 1 Fitting earth rails a) In upper position Before fitting insulating mounting blocks IMB57, check that the swing nuts in the base of each unit are turned back into the moulding. Locate the mounting blocks on the DIN rail in the chosen position and tighten the screws (see figure 4.10). Check that the swing nuts rotate correctly to locate underneath the flanges of the DIN rail. INM 5500 Rev 189 TGL57 TAG57 ERB57 ERB570 ETM7 Snap off extension when using IMB57 as central support 10mm Earth clamp ERB57S in upper position ERB57S in lower position IMB57 Push fastener 14mm Earth-rail clamp ERL7 THR2 IMB57 ERL7 HAZ1-3 HAZ4-6 TH5000 TAG57 TGL57 SAF7-9 SAF10-12 ERB57S ETM7 PWR5000 Figure 4 3: Assembly drawing showing part numbers Figure 4 4: Mounting details Figure 4 5: IMB57 Insulating mounting block Figure 4 6: TAG57 Tagging strip, 1m length Figure 4 7: MS010 DIN rail module spacers Figure 4 8: ETM7 Earth terminals Figure 4 9: Earth rails and clamps INM 5500 Rev 1810 Figure 4 10: Fitting IMB57 Slide a straight earth-rail bracket ERB57S into the upper slot in each mounting block. Push two plastic push fasteners into each bracket to locate the brackets in the mounting blocks. Cut earth rail ERL7 to the length needed. Slide the required number of ETM7 earth terminals (5mm or 7mm wide) onto the rail. Clamp each end of the earth rail to earth-rail brackets ERB57S using the terminal clamps (14mm, 35mm2) supplied. Fit an earth clamp (10mm, 16mm2) to the free end of each earth-rail bracket. Note: For lengths of earth-rail greater than 500mm, provide additional support by installing a third IMB57 mounting block and earth-rail bracket, mid-way between the end mounting blocks. Snap out the perforated extension between the lugs on this mounting block if a continuous tagging strip is to be fitted (see figure 4.6). b) In lower position, where at least 150mm clearance exists on one side, measured from the edge of the mounting block. As for a), but slide earth-rail brackets ERB57S into the lower slots in each mounting block. c) In lower position, where there is insufficient clearance to fit earth-rail brackets ERB57S. As for a), but slide offset earth-rail brackets ERB57O into the upper slot in each mounting block before assembling the mounting blocks to the DIN rail. ERB57S brackets cannot be used because they obscure the fixing screws on the mounting blocks. 4 3 2 2 Fitting tagging strips Assemble mounting blocks IMB57 to the DIN rail as above. Cut TAG57 tagging strip and label to the length needed, and insert label so that the appropriate side is visible. Clip the strip onto the lugs on the mounting blocks. Hinge up the strip to provide access to the tops of the isolators. Note: If necessary, provide additional support for long lengths of tagging strip by installing an extra IMB57 mounting block mid-way between the end mounting blocks. Snap out the perforated extension between the lugs on this mounting block. 4 3 3 Completed assemblies Figure 4.11 illustrates a complete assembly of MTL5500 isolators using the accessories mentioned above. The broken-line boxes either side of the assembly represent cable trunking, and the accompanying dimensions represent the recommended minimum spacing between the trunking and the module assemblies. INM 5500 Rev 1811 Colour Module no Function Yellow MTL5501-SR Digital Inputs White MTL551x Red MTL552x Digital Outputs Blue MTL5531/33 Vibration Purple MTL5532 Pulse Blue MTL5541x MTL5544x Analogue Inputs Green MTL5546x MTL5549x Analogue Outputs Blue MTL556x Fire & Smoke Orange MTL557x MTL558x Temperature inputs Grey MTL5599 Dummy isolator Table 4 2: MTL5500 front label colour coding Figure 4 11: MTL5500 complete assembly INM 5500 Rev 1812 5 DX ENCLOSURES Enclosures are usually selected on the basis of the number of units they will accommodate and Table 5.1 shows the capacity of each of the enclosures. Figure 5.2 shows each type of enclosure containing MTL5500 modules. Table 5 1: DX range of enclosures - module capacities Enclosure Number of MTL5500 isolators 16mm mounting pitch DX070 4 (2*) DX170 10 (8*) (DX430) 26 (24*) no longer available * Use these figures when two IMB57 mounting brackets for tagging/earth-rail accessories are included. Note: The user should be aware that some workshop preparation may be required for the cable gland plates before the enclosure is ready for on-site installation. 5 1 Environmental conditions Environmental conditions that should be taken into account when installing DX enclosures include:- See section Maximum ambient temperature limits 5.1.1 Storage temperatures 5.1.2 Humidity 5.1.3 Corrosion resistance 5.1.4 Flammability 5.1.5 Impact resistance 5.1.6 Chemical resistance 5.1.7 5 1 1 Maximum outside enclosure temperature limits Figure 5 1: Graph depicting outside enclosure temperature limits for DX enclosures used with MTL5500 isolators The maximum outside enclosure temperature depends upon the total power dissipated by the installed modules which, in turn, depends upon their number and type. It can also be influenced by the Authority whose standards may need to be applied to the system, e.g. Baseefa, Factory Mutual Research Corporation, Canadian Standards Association. Figure 5.1 shows, in graphical form, the maximum outside enclosure temperatures (TMO) for given levels of power dissipation. The graph was derived from the following equation and should be used to calculate accurately the suitability of any particular mix of modules. TMO = 60°C - ∂T where ∂T = k1 x P P = total power (watts) dissipated by modules in an enclosure k1 = is a dissipation constant for a given enclosure and module . Select the relevant value from Table 5.2. (60°C is the temperature inside the enclosure) 60 40 20 10 30 50 0 10 20 30 40 Power dissipation (watts) Max. outside enclosure temperature (°C) Enclosures DX070 DX170 DX430 INM 5500 Rev 1813 Figure 5 3: Optimum orientation for wall mounted enclosure DX070 DX170 MTL5500 4.03 1.88 Table 5 2: Dissipation constant k1 for enclosures (°C/watt) Orientation of the enclosures is also important - the optimum position being on a vertical surface with the internal DIN-rail horizontal as shown in Figure 5.3. Any other position can reduce the maximum allowable ambient temperature by up to 5°C. Examples Tables 5.3 and 5.4 list likely combinations of MTL5500 modules in the three enclosure types and indicate the acceptable maximum permitted outside enclosure temperature for these based on the graph in Figure 5.1. See the specifications included in the datasheets for the power dissipation figures of individual MTL5500 modules. Table 5 3: Typical mix of MTL5500 modules Enclosure Modules installed Power dissipation of modules in watts (P) Maximum outside enclosure temp (TMO)°C DX070 2 x MTL5511 + 2 x MTL5544 (2 x 0.72) + (2 x 1.4) = 4.24 42.9 DX170 5 x MTL5511 + 5 x MTL5544 (5 x 0.72) + (5 x 1.4) = 10.6 40.1 Table 5 4: Power versus maximum outside enclosure temperature Enclosure Number of installed modules k °C/watt Power dissipation of modules in watts (P) Maximum outside enclosure temp (TMO) °C DX070 4 4.03 4.0 43.9 4 4.03 6.0 35.8 DX170 10 1.88 10.0 41.2 10 1.88 15.0 31.8 5 1 2 Storage temperatures Storage temperatures are safe within the range -40°C to +80°C. 5 1 3 Humidity limits Safe humidity limits are within the range 5 to 95% RH. 5 1 4 Extended ambient temperature modules Modules with the -T suffix are rated for use in an ambient temperature up to 65°C if suitably certifed. INM 5500 Rev 1814 Figure 5 2: DX range of enclosures 150 DX070 130 113.5 153.5 70 180 163.5 203.5 Ø 5.2 184 147 (inside) Top of DIN rail 270 8080 540 430 520 576 249 305 Ø 7.2 DX430 184 147 (inside) Top of DIN rail 170 249 305 102 102 360 339 395 270 Ø 7.2 DX170 131 (inside) n b DX430 no longer available INM 5500 Rev 1815 5 1 5 Corrosion resistance The effect of corrosion on DX enclosures is negligible. 5 1 6 Flammability rating The flammable properties of the materials used in the construction of the enclosures are well understood by manufacturers and ratings have been established to a number of standards. One of the better known standards is the Underwriter's Laboratory standard UL 94 and the ratings for the enclosure materials are given as: Materials UL94 rating Polycarbonate (all lids) V2/V0 Polycarbonate with glass reinforcement (DX070 base) V1/V0 Polyester with glass reinforcement (DX170 & DX430 bases) V0 Items made from similar materials are well established as suitable for use in process I/O marshalling areas. 5 1 7 Impact resistance The enclosure designs have been tested to an impact resistance of greater than 2 Joules which exceeds the BS EN 61010-1 requirements of 0.5 Joules. 5 1 8 Chemical resistance The overall chemical resistance of the enclosures is limited by the resistance of the transparent polycarbonate lid. The glass-reinforced polycarbonate/polyester (GRP) bases have a higher resistance than plain polycarbonate. Table 5.5 lists qualitative evaluations of resistance to a variety of chemical agents. Table 5 5: Qualitative evaluations of resistance to various chemical agents Chemical agents Qualitative evaluation of resistance Salt water; neutral salts; acids (low concentrations); hydraulic oil Excellent Alcohols Very good Acids (high concentrations); alkalis (low concentrations); petrol; cooling fluids Good Alkalis (high concentrations); solvents. Poor 5 2 Mounting 5 2 1 General These instructions are concerned solely with mounting the DX enclosures. Instructions for wiring and testing individual modules within the enclosures are provided in Section 6. Sufficient space is provided within the enclosures to accommodate tagging and earth-rail accessories but this is at the expense of a reduction in the number of modules that can be fitted. 5 2 2 Location and orientation 5 2 2 1 Location The DX enclosures are intended for safe (non-hazardous) area use. The enclosures are rated NEMA 4X; consequently, in N. America or Canada, assuming the modules have the required approvals, they can be used in Class 1, Division 2 (gases) location, but check with local requirements and ensure all cable entries also conform. In this case, an additional warning label will be required on or near the enclosure warning that the MTL5500 interfaces must not be removed unless the area is known to be non-hazardous. The enclosures are NOT suitable for Class II or III, Division 2 hazardous locations. INM 5500 Rev 1816 5 2 2 2 Orientation As noted earlier (see section 5.1.1), for optimum temperature performance the enclosures should be mounted on a vertical surface with the internal DIN rail horizontal. 5 2 3 Mounting details See Figure 5.2 for the dimensions and mounting hole distances, etc., of the three DX enclosures. The recommended method of mounting-described here-uses the four wall-mounting lugs supplied with each enclosure. An alternative method of mounting is by direct attachment to the mounting surface through the corner holes. Note: When the wall-mounting lugs are used to attach the enclosures, the overall depth of the enclosure is increased by an additional 3.3 mm (DX070) or 7 mm (DX170 and DX430). a) At each of the four corner fixing holes, insert one of the screws provided and use it to attach a fixing lug to the base of the enclosure. b) Each lug can be used in one of two positions as shown in Figure 5.2. c) Attach the lugs to the mounting surface with suitable fasteners. d) Diameters of fixing holes in lugs are 5.5mm (DX070) and 7.0mm (DX170 and DX430) e) Appropriate fixing hole distances are shown in Figures 5.2. 5 2 4 Cable glanding All cables into the enclosures must be glanded to IP65 standards to maintain this rating for the enclosure as a whole. Cable glands and gland plates are not supplied. Glanding requirements vary for each enclosure as follows: DX070 On the DX070, 'knockout' holes are provided, in two different sizes (15.5 mm and 21 mm), on the side faces of the base. See Table 5.7 for recommended cable glands. DX170 The DX170 can accommodate one gland plate on each side - see figure 5.2 for details. Table 5.6 lists suppliers of suitable gland plate kits and Table 5.7 lists recommended glands. Table 5 6: Recommended gland plate kits for the DX170 and DX430 enclosures. Manufacturer/agent Manufacturer's part number Enclosure DX170 Hellermann Tyton TL-27/360 Sarel 21128 Table 5 7: Recommended cable glands for use with DX enclosures. Gland thread size Cable sizes (mm) Gland plate hole size (mm) Weidmuller part nos Sarel part nos Gland Locknut Gland Locknut PG9 5 to 8 15.2 951891 952216 08871 08881 PG13,5 8 to 13 20.4 951893 952218 08873 08883 Weidmuller (UK) http://www.weidmuller.co.uk Sarel (UK) http://www.sarel.co.uk Hellermann Tyton (UK) http://www.hellermantyton.co.uk INM 5500 Rev 1817 5 3 Accessories in enclosures Apart from mounting, there are some other installation details which should be considered before adding the appropriate interface modules and making the necessary cabling connections. A range of accessories is available to accompany the MTL5500 units (see section 4) and the following points should be observed. 5 3 1 Insulating mounting block (IMB57) A pair of these can be attached to the DIN rail, at either end of the modules, to provide a mounting for earth rails. Use of mounting blocks will reduce the space available for isolator modules. 5 3 2 Earth rails (ERL7) Earth rail is produced in 1 metre lengths and will require cutting to length before mounting. ERL7 earth rails can be mounted either side of the modules but are typically mounted on the hazardous side of the DIN rail. 5 3 3 Tagging strip (TAG57 and TGL57) Tagging strip is produced in 1 metre lengths and will require cutting to length before mounting. Similarly, the labels will require cutting to fit the tagging strip. 5 4 IS warning label A 'Take Care' IS warning label is provided inside each enclosure. This should be attached to the inside of the transparent lid when its orientation has been established. INM 5500 Rev 1818 6 UNIT DESCRIPTIONS, SETTING-UP AND CONNECTIONS This section describes the function (briefly), the setting-up procedure and the wiring connections for each MTL5500 unit. For a fuller functional description and a detailed technical specification, refer to the individual datasheets, which can be found on our website at www.eaton.com or in the current MTL IS catalogue. If a fault is suspected, first check that the power LED is lit (not applicable to loop-powered devices). If necessary, check that all signal and power plugs are properly inserted, that no wires are loose and that the unit is mounted correctly. If operation is still suspect, the unit should be replaced with a serviceable unit. There are no replaceable parts inside MTL5500 units, so any that appear to be inoperative should be returned to the manufacturer/supplier for repair or replacement. WARNING When disconnecting units for maintenance purposes, take care to segregate hazardous and safe-area cables. • Short circuit hazardous-area cable cores to an IS earth or insulate and secure the ends. • Insulate and secure safe-area cables. If testing a unit 'in situ' note that the test equipment used MUST be intrinsically safe. The rest of this section is divided into sub-sections based upon the type of module, as follows. 6 1 Digital Input modules MTL5501-SR, MTL5510, MTL5510B, MTL5511, MTL5513, MTL5514, MTL5514-T, MTL5514D, MTL5516C, MTL5517 6 2 Digital Output modules MTL5521, MTL5521 -T, MTL5522, MTL5523, MTL5523V, MTL5523VL, MTL5524, MTL5525, MTL5526 6-3 Vibration, Pulse and Foundation Fieldbus modules MTL5531, MTL5532, MTL5533, MTL5553 6 4 Analogue Input modules MTL5541, MTL5541-T, MTL5541A, MTL5541AS, MTL5541S, MTL5541S-T, MTL5544, MTL5544A, MTL5544AS, MTL5544D, MTL5544S 6 5 Analogue Output modules MTL5546, MTL5546Y, MTL5546Y-T, MTL5549, MTL5549Y 6 5 Fire and Smoke interface modules MTL5561 6 7 Temperature Input modules MTL5573, MTL5575, MTL5576-RTD, MTL5576-THC, MTL5581, MTL5582, MTL5582B 6 8 General modules MTL5599, MTL5991 6 9 PCS45/PCL45USB configurator for MTL temperature converters Note: Any LED indicator provided on the modules will display in the following colours: LED label LED colour PWR (power) Green STS (status) Yellow LFD (line fault) Red FLT (fault) Red OPx (o/p status) Yellow INM 5500 Rev 1819 6 1 Digital Input modules The Digital Input (DI) module range offers solid state or relay output switches in a safe area that respond to input switches located in a hazardous area. Single or multiple channel (2 or 4) options are available, as well as Line-Fault Detection (LFD). Modules with LFD can recognise open or short circuit conditions on the input wires going to the field sensors, and some DI modules have the facility to reverse the effect of the input on the output i.e. phase reversal. These options are chosen with switches located on the edge of the module on the hazardous area terminal side. In some applications it may be easier to set these switches before fitting the module to the DIN-rail. Figure 6 1: Switches to set LFD and phase reversal 6 1 1 Phase reversal Set the PR switch ON or OFF for the appropriate channel(s). 6 1 2 Line-Fault Detection (LFD) Where fitted, set the LF switch ON or OFF for the appropriate channel(s). Note: LFD is permanently active on the MTL5501-SR. For all DI modules with LFD except for the MTL5501-SR; when using the LFD facility with a contact input, resistors must be used. Fit 500Ω to 1kΩ (preferred value 680Ω) in with the switch and 20kΩ to 25kΩ (preferred value 22kΩ) in parallel with the switch. For modes of operation of the MTL5510 & MTL5510B that include LFD, resistors should be fitted as described above. For MTL5501-SR use 1k4Ω in and 10kΩ in parallel with switch contact inputs. For hazardous-area inputs conforming to EN 60947-5-6:2001 (NAMUR), a line fault is judged by the following rules: • Open circuit condition if hazardous-area current 250μA • Short circuit condition if hazardous-area load 360Ω Note: the open circuit window (between 250μA and 50μA), and the short circuit window (between 100Ω and 360Ω), is not hysteresis. All MTL5500 modules, with inputs conforming to EN 60947-5-6:2001 (NAMUR), will switch between open and complete circuit conditions within these limits. The MTL5501-SR LFD relay de-energises when a fault condition is detected. The MTL5514 and the MTL5517 energise the LFD relay to indicate a fault condition. INM 5500 Rev 1820 6 1 3 MTL5501-SR - Fail-safe Switch/Proximity detector interface Single channel, fail-safe module with line-fault detection The MTL5501-SR enables a fail-safe switch/proximity detector located in the hazardous area to be controlled an isolated fail-safe electronic output. It provides line-fault detection (LFD) alarm contacts and is designed for use with approved fail-safe sensors in loops that require operation up to SIL3 according to the functional safety standard IEC 61508. Note: For reliable, long-term operation the load on the LFD switching relay should be not less than 50mW, e.g. 10mA at 5V DC. Hazardous area Safe area Vs– Vs+ 20 to 35V dc 10kΩ 1k4Ω + – LFD Failsafe output + –Resistors must always be fitted for switch inputs 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Terminal Function 1 Input –ve 2 Input +ve 7 Output –ve 8 Output +ve 10 LFD 11 LFD 13 Supply –ve 14 Supply +ve Figure 6 2: Top label for MTL5501-SR Input / output characteristics Input value in sensor circuits Fail–safe output Operation LFD contacts 2.9mA < Is < 3.9mA ON Normal CLOSED Is 5.1mA OFF Normal CLOSED Is < 50μA OFF Broken line OPEN Rs < 100Ω OFF Shorted line OPEN Correct operation of the fail-safe output and LFD is indicated by the LEDs on the front of the unit. The yellow O/P LED is ON when the fail-safe output is energised. The red LFD LED flashes if a line fault is detected. The fail-safe output is de-energised (OFF) if the module detects an incorrect sensor current, an open circuit or a short circuit in the sensor circuit. Input signal sensors may be either suitable proximity sensors or switches. The proximity sensor properties are specified in the standard EN60947-5-6:2001; however, when used with MTL5501-SR modules, additional requirements for the "low-impedance" current of 3.4 ±0.5mA must be met. The list below shows suitable proximity sensors, all manufactured by Pepperl+Fuchs Group, Germany, and specified as usable to SIL3, according to IEC 61508: SJ 2-SN NJ 4-12GK-SN NJ 10-30GK-SN SJ 3,5-SN NJ 5-18GK-SN NJ 15-30GK-SN SJ 3,5-S1N NJ 8-18GK-SN NJ 6S1+U1+N NJ 2-11-SN NJ 6-22-SN NJ 15S+U1+N NJ 2-11-SN-G NJ 6-22-SN-G NJ 20S+U1+N NJ 2-12GK-SN NJ 5-30GK-S1N NJ 40-FP-SN-P1 INM 5500 Rev 1821 6 1 4 MTL5510 & MTL5510B - Switch/Proximity detector interface 4-channel, digital input and multifunction modules These digital modules provide solid state output switches in a safe area that respond to switches (inputs) located in a hazardous area. The way they respond - their "mode" - can be configured using a bank of four DIL selector switches accessible through the side of the module - see Figure 6.4. Model MTL5510 has one output channel for each input channel and the user can reverse the output phase if necessary to suit the application. Model MTL5510B has more varied modes that can, for example, enable one input to affect multiple outputs or create latched outputs, etc.) The channel output transistors - Ch1/Ch2 and Ch3/Ch4 - share a common terminal and can switch +ve or –ve polarity signals. Note that parallel resistors are required for switch inputs with LFD - see Section 6.1.2 for recommended values. Hazardous area Ch B Vs– Vs+ 20 to 35V dc – + – + – + Ch D Ch C Ch A 1 2 3 4 common common Outputs 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Safe area Terminal Function 1 Input channel A 2 Input channel B 3 Input channel C 4 Input channel D 5 Input channel CD common (+) 6 Input channel AB common (+) 7 Output channel 3/4 common 9 Output channel 3 10 Output channel 2 11 Output channel 1/2 common 12 Output channel 1 13 Supply –ve 14 Supply +ve Figure 6 3: Top labels for MTL5510 & MTL5510B INM 5500 Rev 1822 Figure 6 4: DIL switches for setting mode Tables 6.1 and 6.2 show details of the modes available and the switch settings required to obtain them. For ease of access, it is recommended that switches are set to the required mode before installation. Table 6.1 indicates whether the output follows the input, or the output is the reverse or antiphase of the input. For example, in mode 0, o/p 1 = chA; so, if channel A switch is closed, then output 1 will also be closed or short circuit. However, in mode 1, o/p 1 = chA rev., so if channel A switch is closed, then output 1 will be the reverse, i.e. open-circuit. Table 6.2 shows the MTL5510B modes. The logic tables and timing diagrams on the following pages provide more detailed information on these modes. *Mode of operation changed August 2015 MTL5510 & MTL5510B diagnostics If an internal fault is detected, all outputs and channel LEDs will turn off and the red Fault LED will turn ON. Table 6 2 - MTL5510B mode options Switch settings MODE Function Equivalent 1 2 3 4 OFF OFF OFF OFF 0 4-ch switch input (see MTL5510 mode 0) MTL5510 ON OFF OFF OFF 1 2-ch with each input channel, two outputs OFF ON OFF OFF 2* Same as mode 1 with all outputs phase reversed ON ON OFF OFF 3 2-ch, 2-pole changeover output OFF OFF ON OFF 4 1-ch with line fault output MTL5014 ON OFF ON OFF 5 As mode 4 with changeover outputs OFF ON ON OFF 6 1-ch with start-stop latch MTL2210B ON ON ON OFF 7* As mode 2 with LFD enabled OFF OFF OFF ON 8 4-ch switch input, see MTL5510 mode 8 MTL5510 ON OFF OFF ON 9 2-ch with line fault output MTL5017 OFF ON OFF ON 10 As mode 9 with LFD changeover ON ON OFF ON 11 As mode 10 with channel phase reversed OFF OFF ON ON 12 3-ch with normally-open LFD output OFF ON ON ON 13 3-ch with normally-closed LFD output OFF ON ON ON 14 2-ch monostable, pulse stretcher ON ON ON ON 15 4-ch switch input, see MTL5510 mode 15 MTL5510 Table 6 1 - MTL5510 mode options Switch setting MODE o/p 1 o/p 2 o/p 3 o/p 4 1 2 3 4 OFF OFF OFF OFF 0 chA chB chC chD ON OFF OFF OFF 1 chA rev. chB chC chD OFF ON OFF OFF 2 chA chB rev. chC chD [illegible]

power devices that are certified as intrinsically safe or are classified as non-energy- storing simple apparatus. 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Solenoid, alarm or other IS device + – Vs– Vs+ 20 to 35V dc + – Control ‡ ‡ use link to reverse phase Terminal Function 1 Output –ve 2 Output +ve 8 Phase reversal link 9 Phase reversal link 11 Control –ve 12 Control +ve 13 Supply –ve 14 Supply +ve Figure 6 14: Top label for MTL5524 INM 5500 Rev 1835 6 2 6 MTL5525 - Solenoid Alarm driver Single channel, low current, loop powered, IIC The MTL5525 enables an on/off device in a hazardous area (IIC gas group) to be controlled by a switch or voltage change in the safe area. It can drive loads such as solenoids, alarms, LEDs and other low power devices that are certified as intrinsically safe or are classified as non-energy-storing simple apparatus. Similar in function to the MTL5521, this module provides lower power output and corresponding reduced safety description. 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Solenoid, alarm or other IS device 20 – 35Vdc – + + – Hazardous area Safe area Terminal Function 1 Output –ve 2 Output +ve 11 Supply –ve 12 Supply +ve Figure 6 15: Top label for MTL5525 INM 5500 Rev 1836 6 2 7 MTL5526 - Switch Operated Relay Two channel, output The MTL5526 enables two separate IS circuits in a hazardous area to be relay-contact controlled by two on-off switches or logic signals in a safe area. Applications include the calibration of strain–gauge bridges; changing the polarity (and thereby the tone) of an IS sounder; the testing of IS fire alarms; and the transfer of safe-area signals into an annunciator with IS input terminals not segregated from each other. The output–relay contacts are certified as non–energy–storing apparatus, and can be connected to any IS circuit without further certification, provided that separate IS circuits are such that they would remain safe if connected together. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 IS relay IS relay 1 Vs– Vs+ 20 to 35V dc + – 2 + – Control 20 to 35V dc + – + – Loop powered Contact inputs All contacts shown in normal position (relays de-energised) 1 2 Sw4 Hazardous area Safe area Terminal Function 1 IS relay output 1 (normally open) 2 IS relay output 1 (normally closed) 3 IS relay output 1 (common) 4 IS relay output 2 (common) 5 IS relay output 2 (normally closed) 6 IS relay output 2 (normally open) 8 Relay 1 control +ve 9 Relay 1 control –ve 10 Relay 2 control +ve 11 Relay 2 control –ve 13 Supply –ve 14 Supply +ve OFF position ON position 1 2 3 4 Table 6 3: Switch settings for modes Mode Function SW1 SW2 SW3 SW4 Contact/Logic Input 2 ch Off On On On 1in2out On On On Loop Powered 2 ch Off Off On On Figure 6 16: Top label for MTL5526 INM 5500 Rev 1837 6 3 Pulse, Vibration and Foundation Fieldbus modules Single and dual channel modules are available to transfer vibration probe signals from a hazardous area to a safe one. Similarly, pulses from a switch, proximity detector, current pulse transmitter or voltage pulse transmitter, located in the hazardous area, can be safely transferred to the safe area. 6 3 1 MTL5531 - Vibration Transducer Interface Single channel The MTL5531 repeats a signal from a vibration sensor in a hazardous area, providing an output for a monitoring system in the safe area. The interface is compatible with 3-wire, eddy-current probes and accelerometers or 2-wire current sensors, and selection of the mode is made with a switch located on the side of the module Hazardous area Safe area 6 5 4 3 2 1 7 8 9 10 11 12 13 14 COM SIG V– Vibration transducer Vibration transducer Vs– Vs+ 20 to 35V dc –ve 0V Monitor 3- wire 2- wire 2 1 3 Terminal Function 1 Transducer power V– 2 Signal 3 Common 11 Signal output –ve 12 Signal output 0V 13 Supply –ve 14 Supply +ve OFF position ON position 2-/3-wire transducer setting switch Mode SW 2-wire (3 3mA)* OFF 3-wire (20mA) ON * Note: When using 2-wire sensors, ensure that terminals 1 and 2 are linked as shown in the wiring diagram above. WARNING - Revision status 05 and below** To enable optimum heat dissipation the recommended orientation for mounting is with the module vertical, i e with the vents in the case at the top and bottom This enables air to flow through the module In any other orientation, i e with the module horizontal, then the maximum ambient temperature is limited to: • Close packed = 45°C • Minimum of 10mm spacing = 55°C Eaton produce the MS010 DIN rail module spacer for this purpose (packs of 5 - see Section 4 3) *Revision status is the 2 digits after the +++ in the barcode number Figure 6 17: Top label for MTL5531 INM 5500 Rev 1838 6 3 2 MTL5532 - Pulse Isolator Pulse & 4/20mA current outputs The MTL5532 isolates pulses from a switch, proximity detector, current pulse transmitter or voltage pulse transmitter located in a hazardous area. It is ideal for applications involving high pulse rates and fast response times, by repeating the pulses into the safe area, and the transistors used on the pulse output will switch +ve or –ve polarity signals. It may be used immediately in simple or legacy mode, or it may be software configured for more specific applications - see next page for either option. With configuration, an analogue output proportional to frequency is available, together with a relay output, which may act as an alarm. Note: For reliable, long-term operation the load on the output switching relay should not be less than 50mW, e.g.10mA at 5VDC. Hazardous area Safe area 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Vs– Vs+ 20 to 35V dc 3-wire current pulse 4/20 mA + – 3-wire voltage pulse 5 4 1 2-wire current pulse Voltage pulse Current pulse 5 1 Inhibit Load Alarm 4/20mA Configuration socket – + 1 4 + Pulse – + Pulse 4 3 V 4/20 mA 3 1 3 4/20 mA Terminal Function 1 Common input –ve 2 Switch/proximity input +ve 3 Current pulse input +ve 4 Transmitter supply +ve 5 Voltage pulse input +ve 6 Inhibit input +ve 7 Alarm output 8 Current output –ve 9 Current output +ve 10 Alarm output 11 Pulse output –ve 12 Pulse output +ve 13 Supply –ve 14 Supply +ve Vsp SW1 SW2 3V ON ON 6V ON OFF 12V OFF OFF OFF position ON position 1 2 3 4 SW1 SW2 SW3 SW4 Vsp Vsp LFD Mode LFD SW3 OFF OFF ON Switches located on the edge of the module define the mode of operation. Figure 6 18: Top label for MTL5532 INM 5500 Rev 1839 Switch input operation If switch contacts are used for this Pulse Input (terminals 1 & 2), then and parallel resistors must be fitted - see Section 6.1.2 for recommended values. Simple or Legacy mode - SW4 - OFF If simple "pulse-in/pulse-out" operation is required or, if a replacement for the earlier MTL5032 pulse isolator is required, then SW4 should be set to OFF. The input switching point voltage (Vsp) thresholds can then be defined by Switches 1 & 2, and the LFD operation can be set with Switch 3. When Switch 3 is ON, the Alarm output (terminals 11 & 12) become active. Configurable mode - SW4 - ON In this mode, analogue, alarm and pulse outputs are available but the module must be software configured to define its operating mode. In this mode, software controls the LFD function and Switch 3 has no effect. Switches 1 & 2 continue to define the switching point threshold (Vsp). Configuration requires a personal computer, a PCL45USB interface and PCS45 software. See Section 6.9 for details of the configurator. Alarm inhibiting The Inhibit input is provided to inhibit alarm output operation. This facility is useful, for example, during power-up, when pulse rates are below the alarm threshold. When normal operational values are established the inhibit can be disabled. Such a facility is sometimes referred to as a start-up delay. Inhibit is enabled by connecting a switch or proximity detector between terminals 6 and 3. If switch contacts are used for this input, then and parallel resistors must be fitted - see Section 6.1.2 for recommended values. LED indicators Use the following LED information to understand the module status. LED Description PWR Power (green) ON - Power OK OFF - No power or insufficient voltage O/P Output (yellow) The LED will follow the pulse output state. If the output is pulsing then the LED brightness will pulse. If the pulsing is rapid or very short, the LED may dim if it is unable to respond to such changes. If the output is high, the LED will be ON. STS Status (red - flashing) In legacy mode a line fault will cause the LED to turn ON. In mC mode, the LED is programmable to display a line fault or an Alarm trip operation. In the event, it will also indicate a mC fault condition. INM 5500 Rev 1840 6 3 3 MTL5533 - Vibration Transducer Interface (Reference use only: Terminated product, use 2 x MTL5531) Two channel The MTL5533 repeats signals from vibration sensors in a hazardous area, providing outputs for monitoring systems in the safe area. The interface is compatible with 3-wire eddy-current probes and accelerometers or 2-wire current sensors, and selection of the mode for each channel is made with the switches on the side of the module. Hazardous area Safe area Vibration transducer Vibration transducer Vibration transducer Vibration transducer COM SIG V– COM SIG V– Vs– Vs+ 20 to 35V dc –ve 0V Monitor 3- wire 2 1 3- wire 2- wire 5 4 2- wire Monitor –ve 0V 3 6 Ch 1 Ch 2 Ch 1 Ch 2 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Terminal Function 1 Transducer power V– (Ch1) 2 Signal (Ch1) 3 Common (Ch1) 4 Transducer power V– (Ch2) 5 Signal (Ch2) 6 Common (Ch2) 8 Signal output –ve (Ch2) 9 Signal output 0V (Ch2) 11 Signal output –ve (Ch1) 12 Signal output 0V (Ch1) 13 Supply –ve 14 Supply +ve OFF position ON position Ch 1 Ch 2 2-/3-wire transducer setting switches Mode SW 2-wire (3 3mA) OFF 3-wire (20mA) ON * Note: When using 2-wire sensors, ensure that terminals 1 & 2 and 4 & 5 have wiring links as shown in the wiring diagram above. WARNING! To enable adequate heat dissipation from the MTL5533 modules, they must be installed on the DIN rail with a 10mm space between adjacent units Eaton produce the MS010 DIN rail module spacer for this purpose (packs of 5 - see Section 4 3), and these then enable operation at ambient temperatures of up to 50°C in vertical or horizontal orientation Figure 6 19: Top label for MTL5533 INM 5500 Rev 1841 6 3 4 MTL MTL5553 isolator/power supply for 31 25kbit/s fieldbuses The MTL5553 has been specifically developed to extend 31.25kbit/s (H1) fieldbus networks into hazardous areas. It provides power, communication and IS isolation to devices powered through the signal conductors. The MTL5553 complies with the requirements of Fieldbus Foundation™ specified power supply Type 133 (IS power supply). To comply with fieldbus standards, each bus must be terminated at both ends. MTL's FBT1-IS or FCS-MBT fieldbus terminators (see section 6.33?) can be supplied for this purpose or, for installations in which the safe-area bus length is small, the MTL5553 includes an internal safe-area terminator which is enabled by making a link between terminals 7&8 on the top of the unit. For network and termination criteria, check applicable fieldbus standards and specification IEC 61158-2, ISA-S50.02 for 31.25kbit/s fieldbus systems, Foundation™ Fieldbus 31.25kbit/s Physical LayerProfile Specification FF-816 and MTL's Application Brief AB002.) Hazardous area Safe area 20-35V dc Vs+ Vs- +ve –ve +ve –ve Field (31.25kbit/s) 6 3 2 6W Max 8 9 7 14 13 11 10 7 12 Link 7- 8 for Terminator Terminal Function 1 Hazardous-area fieldbus device(s) connection –ve 2 Hazardous-area fieldbus device(s) connection +ve 4 Optional HHC connection –ve 5 Optional HHC connection +ve 7 Link to 8 to enable internal terminator 8 & 11 Safe-area fieldbus device(s) connection –ve 9 & 12 Safe-area fieldbus device(s) connection +ve 13 Supply –ve 14 Supply +ve Note: To assist the process of terminating cable screens, screw terminals have been provided in terminals 3, 6, and 10. Please note, however, that there is no internal connection for these terminals so they are not earthed. NOTE To allow adequate heat dissipation under all likely thermal conditions, it is recommended that MTL5553s are installed on a horizontal DIN-rail mounted on a vertical surface* with a 10mm space between adjacent units. MTL MS010 10mm DIN-rail module spacers are available for this purpose. * If an MTL5553 is mounted in a non-optimum orientation, the maximum operating temperature is reduced to 45°C. INM 5500 Rev 1842 6 4 Analogue Input modules The analogue input (AI) modules support 2-wire or 3-wire 4/20mA or HART transmitters located in a hazardous area; repeating the current in other circuits to drive safe-area loads. 6 4 1 MTL5541/MTL5541-T/MTL5541S (-T) - Repeater Power Supply Single channel, for 2- or 3-wire transmitters The MTL5541 provides a fully-floating dc supply for energising a conventional 2- or 3-wire 4/20mA transmitter located in a hazardous area, and repeats the current in another floating circuit to drive a safe-area load. For HART 2-wire transmitters, the unit allows bi- directional communications signals superimposed on the 4/20mA loop current. Alternatively, the MTL5541S (-T) acts as a current sink for a safe-area connection rather than driving a current into the load. Separately powered current sources, such as 4-wire transmitters, can be connected but will not support HART communication. Hazardous area Safe area 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Vs– Vs+ 20 to 35V dc 4/20mA MTL5541 MTL5541S – 4/20mA Load+ Load + – + Com Tx+ Input I I Terminal Function 1 Current output 2 Transmitter supply +ve 3 Common 10 Output +ve via 220Ω for HART apps. 11 Output +ve (+ve current sink) 12 Output +ve (–ve current sink) 13 Supply –ve 14 Supply +ve Figure 6 20: Top labels for MTL5541 & MTL5541S INM 5500 Rev 1843 6 4 2 MTL5541A/MTL5541AS - Repeater Power Supply Single channel, for 4/20mA, HART® for 2- or 3-wire transmitters The MTL5541A provides an input for separately powered 4/20mA transmitters and also allows bi–directional transmission of HART communication signals superimposed on the 4/20mA loop current. Alternatively, the MTL5541AS acts as a current sink for a safe-area connection rather than driving a current into the load. Hazardous area Safe area Vs– Vs+ 20 to 35V dc – 4/20mA Load +– + MTL5541A MTL5541AS Load + — + 4/20mA 6 5 4 3 2 1 7 8 9 10 11 12 13 14 I I Terminal Function 1 Input –ve 2 Input +ve 11 Output –ve (+ve current sink) 12 Output +ve (–ve current sink) 13 Supply –ve 14 Supply +ve Figure 6 21: Top labels for MTL5541A & MTL5541AS INM 5500 Rev 1844 6 4 3 MTL5544/MTL5544S - Repeater Power Supply Two channel, for 4/20mA HART® for 2- or 3-wire transmitters The MTL5544 provides fully-floating dc supplies for energising two conventional 2-wire or 3-wire 4/20mA or HART transmitters located in a hazardous area, and repeats the current in other circuits to drive two safe-area loads. For HART transmitters, the unit allows bi-directional transmission of digital communication signals superimposed on the 4/20mA loop current. Alternatively, the MTL5544S acts as a current sink for a safe-area connection rather than driving a current into the load. Separately powered current sources, such as 4-wire transmitters, can be connected but will not support HART communication. Hazardous area Safe area Vs– Vs+ 20 to 35V dc – 4/20mA Load + – + Ch 2 Ch 1 MTL5544 MTL5544S Load + – Load + – 4/20mA 4/20mA Ch 2 Ch 1 Com Tx+ Input Com Tx+ Input 6 5 4 3 2 1 7 8 9 10 11 12 13 14 I I I I Terminal Function 1 Ch1 current input 2 Ch1 transmitter supply +ve 3 Ch1 common 4 Ch2 current input 5 Ch2 transmitter supply +ve 6 Ch2 common 7 Ch2 output +ve via 220Ω for HART apps. 8 Ch2 output –ve (+ve current sink) 9 Ch2 output –ve (–ve current sink) 10 Ch1 output +ve via 220Ω for HART apps. 11 Ch1 output –ve (+ve current sink) 12 Ch1 output –ve (–ve current sink) 13 Supply –ve 14 Supply +ve Hazardous area Safe areaThe MTL5544 or MTL5544S can also be used to drive two safe-area loads from a single 2-wire transmitter (i.e. 1 in, 2 out) by interconnecting the input channels as shown in the diagram (right). Note: In this mode the HART data is transferred via channel 1 output only. See also the MTL5544D. Vs– Vs+ 20 to 35V dc – 4/20mA Load + – 4/20mA Load + Ch 2 Ch 1 MTL5544 MTL5544S Load + – Load + – + –4/20mA 6 5 4 3 2 1 7 8 9 10 11 12 13 14 I I I I Figure 6 22: Top labels for MTL5544 & MTL5544S INM 5500 Rev 1845 6 4 4 MTL5544A/MTL5544AS - Current Repeater Two channel, for 4/20mA passive input for HART® transmitters The MTL5544A provides an input for separately powered 4/20mA transmitters and also allows bi–directional transmission of HART communication signals superimposed on the 4/20mA loop current. Alternatively, the MTL5544AS acts as a current sink for a safe-area connection rather than driving a current into the load. Hazardous area Safe area Vs– Vs+ 20 to 35V dc – + Ch 2 Ch 1 + – Ch 1 4/20mA 4/20mA Ch 2 6 5 4 3 2 1 7 8 9 10 11 12 13 14 I I I I MTL5544A MTL5544AS – 4/20mA Load+ Load + — + 4/20mA Load+ Load + — + Terminal Function 1 Ch1 input –ve 2 Ch1 input +ve 4 Ch2 input –ve 5 Ch2 input +ve 8 Ch2 output –ve (+ve current sink) 9 Ch2 output +ve (–ve current sink) 11 Ch1 output –ve (+ve current sink) 12 Ch1 output +ve (–ve current sink) 13 Supply –ve 14 Supply +ve Figure 6 23: Top labels for MTL5544A & MTL5544AS INM 5500 Rev 1846 6 4 5 MTL5544D - Repeater Power Supply Two channel, for 4/20mA HART® for 2- or 3-wire transmitters, two outputs The MTL5544D provides a fully-floating dc supply for energising a conventional 2- or 3-wire 4/20mA transmitter located in a hazardous area, and repeats the current in other circuits to drive two safe-area loads. For HART 2-wire transmitters, the unit allows bi-directional communication of digital communication signals superimposed on the 4/20mA loop current via channel 1 only.Separately powered current sources, such as 4-wire transmitters, can be connected but will not support HART communication. Hazardous area Safe area Vs– Vs+ 20 to 35V dc Ch 2 Ch 1 – 4/20mA Load+ – 4/20mA Load+4/20mA 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Com Tx+ Input I I Terminal Function 1 Current input 2 Transmitter supply +ve 3 Common 7 Ch2 output +ve via 220Ω HART not supported. 8 Ch2 output –ve 9 Ch2 output +ve 10 Ch1 output +ve via 220Ω for HART apps. 11 Ch1 output –ve 12 Ch1 output +ve 13 Supply –ve 14 Supply +ve NOTE: For correct operation of the module, a suitable load must be present on both output channels. This is of particular importance during testing, commissioning or maintenance activities when the temporary disconnection, or absence, of a load can affect the transfer accuracy of the analogue variable. Figure 6 24: Top label for MTL5544D INM 5500 Rev 1847 6 5 Analogue Output modules The analogue output (AO) modules accept 4/20mA floating signals from safe-area controllers to drive current/pressure converters (or any other load up to 800Ω) in a hazardous area. 6 5 1 MTL5546/MTL5546Y(-T) - Isolating Driver Single channel, for 4/20mA, HART® valve positioners with line-fault detection The MTL5546 accepts a 4/20mA floating signal from a safe-area controller to drive a current/ pressure converter (or any other load up to 800Ω) in a hazardous area. For HART valve positioners, the module also permits bi-directional transmission of digital communication signals so that the device can be interrogated either from the operator station or by a hand-held communicator. Process controllers with a readback facility can detect open or short circuits in the field wiring: if these occur, the current taken into the terminals drops to a preset level. The MTL5546Y(-T) is very similar to the MTL5546 except that it provides open circuit detection only (i.e. no short-circuit detection). Hazardous area Safe area Terminal Function 1 Output –ve 2 Output +ve 11 Input –ve 12 Input +ve 13 Supply –ve 14 Supply +ve Input characteristics Field wiring state MTL5546 MTL5546Y Normal <6.0V <6.0V Open-circuit <0.9mA <0.5mA Short-circuit <0.9mA N.A. Figure 6 25: Top labels for MTL5546 & MTL5546Y INM 5500 Rev 1848 6 5 2 MTL5549/ MTL5549Y - Isolating Driver Two channel, for 4/20mA HART® valve positioners with line-fault detection The MTL5549 accepts 4/20mA floating signals from safe-area controllers to drive 2 current/ pressure converters (or any other load up to 800Ω) in a hazardous area. For HART valve positioners, the module also permits bi-directional transmission of digital communication signals so that the device can be interrogated either from the operator station or by a hand-held communicator. Process controllers with a readback facility can detect open or short circuits in the field wiring: if these occur, the current taken into the terminals drops to a preset level. The MTL5549Y is very similar to the MTL5549 except that it provides open circuit detection only (i.e. no short-circuit detection). Hazardous area Safe area Terminal Function 1 Output –ve (Ch 1) 2 Output +ve (Ch 1) 4 Output –ve (Ch 2) 5 Output +ve (Ch 2) 8 Input –ve (Ch 2) 9 Input +ve (Ch 2) 11 Input –ve (Ch 1) 12 Input +ve (Ch 1) 13 Supply –ve 14 Supply +ve Input characteristics Field wiring state MTL5549 MTL5549Y Normal <6.0V <6.0V Open-circuit <0.9mA <0.5mA Short-circuit <50mV <50mV – NO Vin* ON – YES 16.5V. 8 3 2 Modules: MTL5541S(-T), MTL5544S & MTL5561 Figure 8 6: At test circuit #2 "o/p sinking" Output Measurements Note: Do not connect a voltmeter in circuit to measure V1 until requested in Step 4 below, because current measurement A2 could be affected. 1. Adjust RV1 to vary the current (A1) through the range 4 to 20mA. 2. The measured current imbalance (A2) over this range for the MTL5541S and the MTL5544S should not exceed ± 20µA. For the MTL5561 the imbalance should not exceed ± 400µA. 3. Adjust RV1 for a 20mA reading on A1 4. The voltage V1, across the channel input, should typically be >16.5V. + – + – V1 i/p o/p RV1 10kΩ lin. A1 250Ω 24V + – I oli A2 + – INM 5500 Rev 1863 8 3 3 Modules: MTL5541A & MTL5544A Figure 8 7: At test circuit #3 "active i/p" Output Measurements 1. Adjust RV1 to vary the current (A1) through the range 4 to 20mA. 2. The measured current imbalance (A2) over this range should not exceed ± 20mA 8 3 4 Modules: MTL5541AS & MTL5544AS Figure 8 8: At test circuit #4 "active i/p - o/p sinking" Output Measurements 1. Adjust RV1 to vary the current (A1) through the range 4 to 20mA. 2. The measured current imbalance (A2) over this range should not exceed ± 20mA INM 5500 Rev 1864 8 3 5 Module: MTL5581 Figure 8 9: At test circuit #5 "mV input" Note: V1 should be capable of measurement to within ½mV. Output Measurements 1. With the LINK connected, vary output V2 between 0 and 50mV using RV1. V1 should show <0mV with the switch set to '+', or 19V. Vary the potentiometer setting and check that the reading on voltmeter V varies by no more than ±100mV. + – + – A2 + – A1 o/p i/p current source +– 470Ω load I oli INM 5500 Rev 1866 8 5 2 Testing MTL5553 - Isolator/power supply for 31 25kbits/s fieldbuses Make the safe and hazardous-area connections shown in figure 10.2 and, substituting appropriate resistors at Rtest, carry out the following checks. Rtest Voltage across terminals 2 and 1 (V1) Open-circuit 17.8 < V1 < 19V 220Ω 11.5V < V1 < 13.5V 10Ω V1 < 5V 20-35V dc Vs- Vs+ +ve –ve Host (31.25kbit/s) Terminator 1 2 4 5 6 3 2.6W Max 8 9 7 14 13 11 10 7 12 Link 7- 8 for Terminator Hazardous Area Safe Area V1 R test + - Top Label, MTL5553 Test circuit for MTL5553 INM 5500 Rev 1867 9 APPLICATIONS INVOLVING ZONE 2 AND/ OR ZONE 22 HAZARDOUS AREAS IMPORTANT! See page iv at the front of this manual for important additional information regarding the use of these products in countries governed by the ATEX Directive. The European Community permits Category 3G equipment, such as the MTL5500 , to be installed in, or connected to, Zone 2 flammable atmospheres provided it meets the requirements of the ATEX Directive. MTL5500 Category 3 products have been designed to meet, and carry approval markings for, Ex nC and/or Ex nA. In general, meeting the relevant requirements of the appropriate European (CENELEC) standards is considered the most appropriate method of demonstrating compliance with the ATEX directive. However, Eaton often has its products approved by other national bodies, such as FM and CSA and, because national, European, and international standards are converging, it is generally possible to use other national approvals as supporting evidence for the ATEX Technical File. In the context of this document, Zone 2 (Division 2) and Zone 22 hazardous areas are those that may become potentially explosive through the presence of flammable gases, vapours and dusts for periods of up to 10 hours per year. It is recommended that the current version of the standards is consulted for detailed information on the requirements applicable to the particular installation. As a consequence of their IS approvals, MTL5500 products may also be connected to circuits that enter Zone 22 hazardous areas. Consult individual module approvals for further details. Unless otherwise specified, the following ambient conditions apply: Ambient Temperature range –20°C to +60°C Pollution Degree 2 (See EN 61010-1) Measurement Category II (See EN 61010-1) 9 1 Enclosure EN 60079-15 specifies the minimum required degree of protection to be IP54, but generally this is provided by the external enclosure in which the product is mounted. The user must refer to the specific certificates relating to the products being installed within the hazardous area to check that all special conditions of safe use have been complied with. INM 5500 Rev 1868 10 APPENDIX 1 10 1 MTL5000 Many modules in the MTL5000 Isolating Interface Units range have now been superceded by their equivalent in the MTL5500. For new applications the MTL5500 modules are recommended, these offer all the benefits of greater efficiency, new multichannel modules and new functionality. A number of the products in the MTL5000 will continue to provide key functionality as part of MTL DIN rail isolator range and are described within this Appendix. Important • Make sure that all installation work is carried out in accordance with all relevant local standards, codes of practice and site regulations. • When planning the installation of MTL5000 isolators it is essential to make sure that intrinsically safe and non-intrinsically safe wiring is segregated, and that units are installed as required by a nationally accepted authority or as described in EN 60079-14, ISA RP 12.6 or DIN VDE-165. • Check that the hazardous-area equipment complies with the descriptive system document. • If in doubt, refer to the certificate/catalogue for clarification of any aspects of intrinsic safety or contact Eaton's MTL product line or your local representative for assistance. • Make sure the correct hazardous-area connector (field-wiring plug) is plugged into the corresponding isolator. It is recommended that the connector is identified by the same tag number as the matching isolator. Mount all MTL5000 isolators on low-profile (7mm) or high-profile (15mm) type T35 (top-hat) DIN-rail to EN50022, BS5584, DIN46277. This is available from Eaton, in 1 metre lengths (THR2 - DIN rail). Install isolators within the safe area unless they are enclosed in approved flameproof, pressurised or purged enclosures and ensure that the local environment is clean and free of dirt and dust. Note the ambient temperature considerations of section 3.1.4. It is recommended that, in normal practice, the DIN rail should be earthed/grounded to ensure the safety of personnel in the event of a.c. mains (line) power being applied accidentally to the rail. Power connectors 104 115 110 16 16.2mm PITCH HAZ SAFE Hazardous-area connections Non-hazardous (safe) area connections INM 5500 Rev 1869 10 2 MTL5018AC Single pole, changeover relay, two-channel, switch/proximity detector with line fault detection and phase reversal The MTL5018AC modules enable each of two safe-area loads to be relay-controlled by switches or proximity detectors in a hazardous area. Line fault detection (LFD) and output phase reversal facilities are included (see section 6.1). 10 2 1 Wiring connections See figure 10.1 for wiring connections. Note: Reactive loads must be adequately suppressed. 10 2 2 Line fault detection (See section 6.1 for definition of a line fault) On each channel, input line faults (open- or short-circuit) are indicated by an LED and the de-energising of the output. LFD is enabled/disabled by switches located on the top of the module. Note: that if the LFD facility is enabled for switch inputs, the resistors shown in 10.1 and 10.2 MUST be fitted. Terminal Function 1 Input –ve (Ch 1) 2 Input +ve (Ch 1) 4 Input –ve (Ch 2) 5 Input +ve (Ch 2) 6 7 Normally-closed contact (Ch 2) 8 Common (Ch 2) 9 Normally-open contact (Ch 2) 10 Normally-closed contact (Ch 1) 11 Common (Ch 1) 12 Normally-open contact (Ch 1) 13 Supply N 14 Supply L Hazardous area Safe area Figure 10 1: MTL5018AC wiring diagram and connections INM 5500 Rev 1870 10 2 3 Testing Make the safe- and hazardous-area connections shown in figure 10.2, and check the status of the output contacts for each channel in turn (with a 22kΩ resistor connected to the other channel) as shown in the table 10.1. Phase reverse switch Line fault detection Input switch (SW) Output relay (11-12, 8-9) Output relay (10-11, 7-8) Channel status LED (yellow) Line fault LED (red) Normal Off a Closed Open On Off Reverse Off ISC = 7 _ 9mA Open Closed Off Off Reverse Off Open Closed Open Off Off Normal On VOC = 7.5 _ 9.5V Open Closed Off On Normal On a Open Closed Off On Normal On c Closed Open On Off Figure 10 2: Test circuit for MTL5018AC Table 10 1 INM 5500 Rev 1871 10 3 MTL5051 serial data comms isolator The MTL5051provides either bi-directional serial data communications from a computer system in a safe area to instrumentation in a hazardous area. It is used to provide a fully floating dc supply for, and serial data communications to MTL640 text displays and MTL650 text and graphics terminals or to other IS and non-IS instrumentation and keyboards. 10 3 1 Wiring connections See the figures 10.3 and 10.4 and the terminal specifications in tables 10.2 and 10.3 for wiring connections. Figure 10.3: MTL5051 wiring diagram (to a hazardous area) Hazardous area Safe area Safe areaHazardous area Figure 10.4: MTL5051 wiring diagram (across a hazardous area) INM 5500 Rev 1872 10 3 2 Hazardous-area interfacing Displays/terminals: For details of interfacing with MTL640 and MTL650 displays/terminals (as an alternative to the MTL696 communications interface) see the appropriate product instruction manual. Table 10 2 MTL5051 Terminals MTL640 mode MTL650 Comms mode Other IS devices 1 Common Common Common Common 2 V signal 12V - 5V/12V 3 I return Rx Rx - 4 - Tx Tx - 5 - - - Tx 6 - - - Rx Switch 1a On Off Off Off 1b On Off Off On Off 10 3 Terminals RS232 mode TTL mode RS422 mode 7 - - Rx- 8 - - Rx+ 9 - Tx Tx+ 10 Tx - Tx- 11 Common Common Common 12 Rx Rx - 13 Supply -ve Supply -ve 14 Supply +ve Supply +ve Switch 2a Off On On 2b On Off Off Across hazardous areas: For communication across hazardous areas, two MTL5051 devices are used in pairs to transfer bi-directional full duplex data across hazardous areas, as shown in figure 10.4. Current switching is used to minimise the bandwidth-limiting effects of long cables. The maximum baud rate in this mode is the lesser of 19.2k baud or the cable-related rate produced by the following formula. Remote signalling baud rate formula, for back-to-back mode across a hazardous area: max baud rate = K/(RxCxL2) where K = 0.25 (constant) R = cable resistance (Ω/m) C = cable capacitance (F/m) L = length (m) For example, with a 2km cable of 100pF/m capacitance and 40mΩ/m resistance, the maximum baud rate = 0.25/(40mΩ x 100pFx 2km2) = 15k baud. This assumes that the cable is 2 cores plus screen, with the screen used for the 'common' connection. RS232-level devices: Communication with RS232-level interfaces, such as a suitably certified IS keyboard, mouse, etc, is achieved by using one or more MTL5051 units as required by the IS device.(TTL level interfaces are accommodated by the TTL compatibility of RS232 receivers.) The supply to IS equipment at terminal 2 can be set to either 5V or 12V, by a switch located on top of the unit, as follows: +12V mode 12.0V ±5% (load 23mA to 23mA to <50mA) Note: the normal RS232 limitations of bandwidth versus cable length apply. As a rule of thumb, speed (baud) x length (metres) tnp setting • open closed H (high) Input tnp setting closed open L (low) Input Industry Events & Webinars•Industry Automation Control Blog• ... •mySchneider Terms of Use • ... •Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric mySchneider Sustainability School: Training you for success Everything you need to know to thrive in the New Electric World Turn your climate ambition into action At Schneider Electric, we're training partners worldwide to enable sustainable practices and decarbonize the economy. Our Sustainability School provides the knowledge and tools you need to differentiate your business and win more projects! Chapter 1 courses – two levels! In our FUNDAMENTAL and ADVANCED Chapter 1 courses, discover why the low-carbon transition is key to reducing and preventing global warming. FUNDAMENTAL-LEVEL In this FUNDAMENTAL-LEVEL course, learn the truth about climate cycles and climate change and why the low-carbon transition is key to reducing and preventing global warming. Register now! ADVANCED-LEVEL In this ADVANCED-LEVEL course, discover the impacts of climate change on our lives and economies and how human progress and why their overexploitation is a threat today. Register now! Chapter 2: Take action! Available Q2 2023! Learn how you can turn your sustainability knowledge into business opportunities, using our tools to launch a decarbonization strategy and action plan for you and your customers. Chapter 3: Win business! Available Q1 2024! Learn how to pitch sustainability and decarbonization to new and existing customers. And discover how to leverage applications and solutions from Schneider Electric to gain business. Discover EcoStruxure Building Operation Software Turn system data into actionable insights EcoStruxure Building Operation is an open and scalable software platform providing insight, control and management of multiple building systems and devices in one mobile-enabled convenient view. It delivers valuable data for decision-making to improve energy management and increase efficiency for better building performance and comfort, reduced carbon, and more sustainable building environments. oRequest a demo opens in new window Benefits of EcoStruxure Building Operation Software Flexibility Modular and scalable architecture with customisable, persona-based views of buildings of any size or complexity. Mobile-ready and accessible on PC, tablet, or smartphone to ensure efficiency. Open integration Tested, interoperable integration of multiple systems from inside and outside the building, native support of standard protocols and MQTT, and seamless access to third-party tools. Simple to upgrade Upgrade and expand on your terms – over time or at once with multi-version support – with continuous access to the latest version through subscription-based software assurance. Cybersecurity Reduced cyber threat risk with a Secure Development Lifecycle (SDLV2) policy, advanced encryption and authentication, and built-in protection against software alterations. Features Further explore EcoStruxure Building Operation Software Supervision and management Engineering tools Specialised integrations Data capturing Designed for buildings of any size, the Enterprise Server not only collects building data, but also configures, controls, and monitors the entire system. With Enterprise Central, a supervisory server for up to 50 integrated Enterprise Servers and hosting up to 2,500 automation servers, you can easily scale operations management across the largest enterprise from a single location. Learn more about Enterprise Central opens in new window Learn more about Enterprise Server opens in new window Collect data Created with accessibility and user experience in mind, WebStation and WorkStation allow users to view and manage data with state-of-the-art graphics, alarms, scheduling, trend logs and reports. In addition to building operations insights, WebStation provides an optimised mobile experience, enabling convenient access to building data at any time and place without additional software installations. Learn more about WebStation opens in new window Learn more about WorkStation opens in new window EcoStruxure Building Commission This mobile app increases project speed with flexible, ladder-free commissioning of controllers, and eliminates dependencies on network infrastructure. Project Configuration Tool This offline engineering platform enables engineers to spend less time at customer sites. Design, programme, model and analyse solutions in a virtual environment without the need for hardware. Automated Engineering Tool This cloud-based tool drives efficiency and standardisation with a large selection of tried-and-true standard HVAC applications and components. Modernised Programming This visual object-orientated system streamlines programming, lowers personnel requirements and project costs while keeping maintaining customizability. Regulated Industries Compliance Pack Get facility-wide accountability and traceability of environmental and security conditions that can impact the quality and safety of controlled environments. Comply with FDA 21 CFR Part 11 and ALCOA principals. Learn more opens in new window EcoStruxure Power Monitoring Expert Only Schneider Electric integrates building and power management in a single view. Our power management software ensures electrical network health, increases power quality awareness, and improves energy usage accountability. Learn more EcoStruxure Smart Connector An open-source developer framework, including SDK, for linking third-party systems to create innovative new capabilities, applications, and solutions that extend and enhance the BMS. Learn more opens in new window EVlink Pro AC Monitor and control onsite electric vehicle (EV) charger energy consumption in a single view with building and power systems. See the charging stations' impact on your building's load demand and power quality, then adjust as needed. Delivering value to every stakeholder See what our customers say about EcoStruxure Building Operation Aspiria This 200-acre mixed-use campus has improved staff productivity and shrunk its carbon footprint by over 10,000 tons. Read the story Resorts World The newest Las Vegas Strip landmark ensures sustainability and scales operations efficiently to meet changing demands. Read the story UST This digital services company unified operations of HVAC, lighting, power, CCTV, and third-party systems at their headquarters in India. Read the story University of Nottingham One of the United Kingdom's biggest universities improved campus operations and provided a more comfortable learning environment. Read the story opens in new window Experience EcoStruxure Building Operation today Explore the features of EcoStruxure Building Operation Software. Review example dashboards, reports, and alerts. Register for a demo Additional resources Explore the EcoStruxure Building Operation BMS Discover Buildings of the Future White Paper: Assessing the "openness" of a BMS White Paper: Three elements of next generation BMS View our portfolio of Smart Building solutions SpaceLogic™ RP-C Controller HVAC Thermostats Discover EcoStruxure Building Operation Software Turn system data into actionable insights EcoStruxure Building Operation is an open and scalable software platform providing insight, control and management of multiple building systems and devices in one mobile-enabled convenient view. It delivers valuable data for decision-making to improve energy management and increase efficiency for better building performance and comfort, reduced carbon, and more sustainable building environments. oRequest a demo opens in new window Benefits of EcoStruxure Building Operation Software Flexibility Modular and scalable architecture with customisable, persona-based views of buildings of any size or complexity. Mobile-ready and accessible on PC, tablet, or smartphone to ensure efficiency. Open integration Tested, interoperable integration of multiple systems from inside and outside the building, native support of standard protocols and MQTT, and seamless access to third-party tools. Simple to upgrade Upgrade and expand on your terms – over time or at once with multi-version support – with continuous access to the latest version through subscription-based software assurance. Cybersecurity Reduced cyber threat risk with a Secure Development Lifecycle (SDLV2) policy, advanced encryption and authentication, and built-in protection against software alterations. Features Further explore EcoStruxure Building Operation Software Supervision and management Engineering tools Specialised integrations Data capturing Designed for buildings of any size, the Enterprise Server not only collects building data, but also configures, controls, and monitors the entire system. With Enterprise Central, a supervisory server for up to 50 integrated Enterprise Servers and hosting up to 2,500 automation servers, you can easily scale operations management across the largest enterprise from a single location. Learn more about Enterprise Central opens in new window Learn more about Enterprise Server opens in new window Collect data Created with accessibility and user experience in mind, WebStation and WorkStation allow users to view and manage data with state-of-the-art graphics, alarms, scheduling, trend logs and reports. In addition to building operations insights, WebStation provides an optimised mobile experience, enabling convenient access to building data at any time and place without additional software installations. Learn more about WebStation opens in new window Learn more about WorkStation opens in new window EcoStruxure Building Commission This mobile app increases project speed with flexible, ladder-free commissioning of controllers, and eliminates dependencies on network infrastructure. Project Configuration Tool This offline engineering platform enables engineers to spend less time at customer sites. Design, programme, model and analyse solutions in a virtual environment without the need for hardware. Automated Engineering Tool This cloud-based tool drives efficiency and standardisation with a large selection of tried-and-true standard HVAC applications and components. Modernised Programming This visual object-orientated system streamlines programming, lowers personnel requirements and project costs while keeping maintaining customizability. Regulated Industries Compliance Pack Get facility-wide accountability and traceability of environmental and security conditions that can impact the quality and safety of controlled environments. Comply with FDA 21 CFR Part 11 and ALCOA principals. Learn more opens in new window EcoStruxure Power Monitoring Expert Only Schneider Electric integrates building and power management in a single view. Our power management software ensures electrical network health, increases power quality awareness, and improves energy usage accountability. Learn more EcoStruxure Smart Connector An open-source developer framework, including SDK, for linking third-party systems to create innovative new capabilities, applications, and solutions that extend and enhance the BMS. Learn more opens in new window EVlink Pro AC Monitor and control onsite electric vehicle (EV) charger energy consumption in a single view with building and power systems. See the charging stations' impact on your building's load demand and power quality, then adjust as needed. Delivering value to every stakeholder See what our customers say about EcoStruxure Building Operation Aspiria This 200-acre mixed-use campus has improved staff productivity and shrunk its carbon footprint by over 10,000 tons. Read the story Resorts World The newest Las Vegas Strip landmark ensures sustainability and scales operations efficiently to meet changing demands. Read the story UST This digital services company unified operations of HVAC, lighting, power, CCTV, and third-party systems at their headquarters in India. Read the story University of Nottingham One of the United Kingdom's biggest universities improved campus operations and provided a more comfortable learning environment. Read the story opens in new window Experience EcoStruxure Building Operation today Explore the features of EcoStruxure Building Operation Software. Review example dashboards, reports, and alerts. Register for a demo Additional resources Explore the EcoStruxure Building Operation BMS Discover Buildings of the Future White Paper: Assessing the "openness" of a BMS White Paper: Three elements of next generation BMS View our portfolio of Smart Building solutions SpaceLogic™ RP-C Controller HVAC Thermostats Galaxy VX 480 V UPS System Technical Specifications Latest updates are available on the Schneider Electric website 11/2024 www.se.com Legal Information The information provided in this document contains general descriptions, technical characteristics and/or recommendations related to products/solutions. This document is not intended as a substitute for a detailed study or operational and site-specific development or schematic plan. It is not to be used for determining suitability or reliability of the products/solutions for specific user applications. It is the duty of any such user to perform or have any professional expert of its choice (integrator, specifier or the like) perform the appropriate and comprehensive risk analysis, evaluation and testing of the products/solutions with respect to the relevant specific application or use thereof. The Schneider Electric brand and any trademarks of Schneider Electric SE and its subsidiaries referred to in this document are the property of Schneider Electric SE or its subsidiaries. All other brands may be trademarks of their respective owner. This document and its content are protected under applicable copyright laws and provided for informative use only. No part of this document may be reproduced or transmitted in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise), for any purpose, without the prior written permission of Schneider Electric. Schneider Electric does not grant any right or license for commercial use of the document or its content, except for a non-exclusive and personal license to consult it on an "as is" basis. Schneider Electric reserves the right to make changes or updates with respect to or in the content of this document or the format thereof, at any time without notice. To the extent permitted by applicable law, no responsibility or liability is assumed by Schneider Electric and its subsidiaries for any errors or omissions in the informational content of this document, as well as any non-intended use or misuse of the content thereof. Access to Your Product Manuals Online Find the UPS Manuals, Submittal Drawings, and Other Documentation for Your Specific UPS Here: In your web browser, type in https://www.go2se.com/ref= and the commercial reference for your product. Example: https://www.go2se.com/ref=GVX1500K1500GS Find the UPS Manuals, Relevant Auxiliary Product Manuals, and Option Manuals Here: Scan the QR code to go to the Galaxy VX online manual portal: UL (480 V) https://www.productinfo.schneider-electric.com/galaxyvx_ul/ Here you can find your UPS installation manual, UPS operation manual, and UPS technical specifications. You can also find installation manuals for your auxiliary products and options. This online manual portal is available on all devices and offers digital pages, search functionality across the different documents in the portal, and PDF download for offline use. Learn More About the Galaxy VX Here: Go to https://www.se.com/ww/en/product-range/63732 to learn more about this product. 990-5451K-001 3 480 V UPS System Technical Specifications Table of Contents Important Safety Instructions — SAVE THESE INSTRUCTIONS

 6 990-5451K-001 Important Safety Instructions — SAVE THESE INSTRUCTIONS Read these instructions carefully and look at the equipment to become familiar with it before trying to install, operate, service or maintain it. The following safety messages may appear throughout this manual or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure. The addition of this symbol to a "Danger" or "Warning" safety message indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed. This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages with this symbol to avoid possible injury or death. DANGER DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury. Failure to follow these instructions will result in death or serious injury. WARNING WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury. Failure to follow these instructions can result in death, serious injury, or equipment damage. CAUTION CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury. Failure to follow these instructions can result in injury or equipment damage. NOTICE NOTICE is used to address practices not related to physical injury. The safety alert symbol shall not be used with this type of safety message. Failure to follow these instructions can result in equipment damage. Please Note Electrical equipment should only be installed, operated, serviced, and maintained by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material. A qualified person is one who has skills and knowledge related to the construction, installation, and operation of electrical equipment and has received safety training to recognize and avoid the hazards involved. 990-5451K-001 7 Important Safety Instructions — SAVE THESE INSTRUCTIONS 480 V UPS System FCC Statement NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. Safety Precautions DANGER HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH • The product must be installed according to the specifications and requirements as defined by Schneider Electric. It concerns in particular the external and internal protections (upstream circuit breakers, battery circuit breakers, cabling, etc.) and environmental requirements. No responsibility is assumed by Schneider Electric if these requirements are not respected. • After the UPS system has been electrically wired, do not start up the system. Start-up must only be performed by Schneider Electric. Failure to follow these instructions will result in death or serious injury. DANGER HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH The UPS System must be installed according to local and national regulations. Install the UPS according to: • IEC 60364 (including 60364–4–41- protection against electric shock, 60364– 4–42 - protection against thermal effect, and 60364–4–43 - protection against overcurrent), or • NEC NFPA 70 depending on which one of the standards apply in your local area. Failure to follow these instructions will result in death or serious injury. DANGER HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH • Install the UPS system in a temperature controlled area free of conductive contaminants and humidity. • Install the UPS system on a non-inflammable, level, and solid surface (e.g. concrete) that can support the weight of the system. Failure to follow these instructions will result in death or serious injury. 8 990-5451K-001 480 V UPS System Important Safety Instructions — SAVE THESE INSTRUCTIONS DANGER HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH The UPS is not designed for and must therefore not be installed in the following unusual operating environments: • Damaging fumes • Explosive mixtures of dust or gases, corrosive gases, or conductive or radiant heat from other sources • Moisture, abrasive dust, steam or in an excessively damp environment • Fungus, insects, vermin • Salt-laden air or contaminated cooling refrigerant • Pollution degree higher than 2 according to IEC 60664-1 • Exposure to abnormal vibrations, shocks, and tilting • Exposure to direct sunlight, heat sources, or strong electromagnetic fields Failure to follow these instructions will result in death or serious injury. NOTICE RISK OF OVERHEATING Respect the clearance requirements around the UPS system and do not cover the product's ventilation openings when the UPS system is in operation. Failure to follow these instructions can result in equipment damage. NOTICE RISK OF EQUIPMENT DAMAGE Do not connect the UPS output to regenerative load systems including photovoltaic systems and speed drives. Failure to follow these instructions can result in equipment damage. 990-5451K-001 9 Important Safety Instructions — SAVE THESE INSTRUCTIONS 480 V UPS System Technical Data System Overview Galaxy VX UPS consists of the following components: • An I/O cabinet for wield wiring containing the static switch, a backfeed breaker BF21, and the user interface. • A number of 250 kW power cabinets containing the power electronics. UPSs with 1250 kW I/O Cabinet The 1250 kW I/O cabinet is used for UPS systems from a minimum configuration of 500 kW with one power cabinet up to a maximum configuration of 1250 kW N+1 with six power cabinets. The I/O cabinet is placed to the left and two to six power cabinets (depending on system size) are placed to the right. The image below shows the maximum configuration. UPSs with 1500 kW I/O Cabinet The 1500 kW I/O cabinet is used for UPS systems from a minimum configuration of 500 kW with two power cabinets to a maximum configuration of 1500 kW N+1 with seven power cabinets. The image below shows the maximum configuration. 10 990-5451K-001 480 V UPS System Technical Data 1. For a 1250 kW I/O cabinet, the BF2 can be installed internal in the UPS or externally in the switchgear. Maintenance Bypass Cabinet for UPSs with a Maximum Rating of 750 kW The maintenance bypass cabinet contains the following breakers to isolate the UPS during maintenance: • Static switch input breaker (SSIB) • Maintenance bypass breaker (MBB) • Unit output breaker (UOB) Maintenance Bypass Cabinet 990-5451K-001 11 Technical Data 480 V UPS System Model List UPSs with 1250 kW I/O Cabinet • Galaxy VX 500 kW, 480 V, start-up 5x8 (GVX500K500NGS) • Galaxy VX 500 kW scalable to 750 kW 480 V, start-up 5x8 (GVX500K750NGS) • Galaxy VX 500 kW scalable to 1000 kW 480 V, start-up 5x8 (GVX500K1000NGS) • Galaxy VX 500 kW scalable to 1250 kW 480 V, start-up 5x8 (GVX500K1250NGS) • Galaxy VX 625 kW, 480 V, start-up 5x8 (GVX625K625NGS) • Galaxy VX 625 kW scalable to 1000 kW 480 V, start-up 5x8 (GVX625K1000NGS) • Galaxy VX 500 kW N+1 redundant UPS 480 V, start-up 5x8 (GVX750K500NGS) • Galaxy VX 750 kW, 480 V, start-up 5x8 (GVX750K750NGS) • Galaxy VX 750 kW scalable to 1000 kW 480 V, start-up 5x8 (GVX750K1000NGS) • Galaxy VX 750 kW scalable to 1250 kW 480 V, start-up 5x8 (GVX750K1250NGS) • Galaxy VX 800 kW, 480 V, start-up 5x8 (GVX800K800NGS) • Galaxy VX 750 kW N+1 redundant UPS 480 V, start-up 5x8 (GVX1000K750NGS) • Galaxy VX 1000 kW, 480 V, start-up 5x8 (GVX1000K1000NGS) • Galaxy VX 1000 kW scalable to 1250 kW 480 V, start-up 5x8 (GVX1000K1250NGS) • Galaxy VX 1100 kW, 480 V, start-up 5x8 (GVX1100K1100NGS) • Galaxy VX 1000 kW N+1 redundant UPS 480 V, start-up 5x8 (GVX1250K1000NGS) • Galaxy VX 1250 kW, 480 V, start-up 5x8 (GVX1250K1250NGS) • Galaxy VX 1100 kW N+1 Redundant UPS 480 V, Start up 5x8 (GVX1500K1100NGS) • Galaxy VX 1250 kW N+1 Redundant UPS 480 V, start-up 5x8 (GVX1500K1250NGS) • Galaxy VX 1250 kW I/O Cabinet without Backfeed protection on Mains 2 (GVXI1250KDNBF2)2. Requires ordering the 250 kW power cabinets separately. 12 990-5451K-001 480 V UPS System Technical Data 2. Backfeed protection can be installed internally in the 1250 kW I/O cabinet with the optional backfeed kit (GVXOPT001) (ordered separately), or installed externally upstream of the UPS in the switchgear. UPSs with 1500 kW I/O Cabinet • Galaxy VX 500 kW 480 V scalable to 1500 kW, start-up 5x8 (GVX500K1500GS) • Galaxy VX 750 kW 480 V scalable to 1500 kW, start-up 5x8 (GVX750K1500GS) • Galaxy VX 1000 kW scalable to 1500 kW 480 V, start-up 5x8 (GVX1000K1500GS) • Galaxy VX 1250 kW 480 V scalable to 1500 kW, start-up 5x8 (GVX1250K1500GS) • Galaxy VX 1500 kW 480 V, start-up 5x8 (GVX1500K1500GS) • Galaxy VX 1500 kW N+1 Redundant UPS 480 V, start-up 5x8 (GVX1750K1500GS) 990-5451K-001 13 Technical Data 480 V UPS System Overview of Configurations Breakers in the System UIB Unit input breaker SSIB Static switch input breaker BB Battery breaker MBB Maintenance bypass breaker UOB Unit output breaker BF2 Backfeed protection switch Overview of UPSs with 1250 kW I/O Cabinet - Single Utility/Mains NOTE: Depending on your chosen configuration, the backfeed breaker BF2 (marked with * in the illustration) can be preinstalled in the UPS, delivered as an optional backfeed kit GVXOPT001 to be installed in the UPS, or installed upstream of the UPS in the switchgear. The illustration shows a 750 kW UPS. The principle is the same for the other UPSs with the 1250 kW I/O cabinet. 14 990-5451K-001 480 V UPS System Technical Data Overview of UPSs with 1250 kW I/O Cabinet - Dual Utility/Mains NOTE: Depending on your chosen configuration, the backfeed breaker BF2 (marked with * in the illustration) can be preinstalled in the UPS, delivered as an optional backfeed kit GVXOPT001 to be installed in the UPS, or installed upstream of the UPS in the switchgear. The illustration shows a 750 kW UPS. The principle is the same for the other UPSs with the 1250 kW I/O cabinet. Overview of UPSs with 1500 kW I/O Cabinet – Single Utility/Mains The illustration shows a 1500 kW UPS. The principle is the same for the other UPSs with the 1500 kW I/O cabinet. Galaxy VX 1500 kW UPS 990-5451K-001 15 Technical Data 480 V UPS System Overview of UPSs with 1500 kW I/O Cabinet – Dual Utility/Mains The illustration shows a 1500 kW UPS. The principle is the same for the other UPSs with the 1500 kW I/O cabinet. Galaxy VX 1500 kW UPS Parallel System Galaxy VX can support up to 4+0 UPSs in parallel for capacity and up to 4+1 UPSs in parallel for

redundancy. NOTE: Note that for systems over 4 MW it can be difficult to find appropriate breakers/switches in the correct size for the switchgear. 16 990-5451K-001 480 V UPS System Technical Data Input Power Factor 500 kW 625 kW 750 kW 800 kW 1000 kW 1100 kW 1250 kW 1500 kW 25% load 0.98 0.98 0.98 0.98 0.98 0.98 0.98 0.98 50% load 0.99 0.99 0.99 0.99 0.99 0.99 0.99 0.99 75% load 0.99 0.99 0.99 0.99 0.99 0.99 0.99 0.99 100% load 0.99 0.99 0.99 0.99 0.99 0.99 0.99 0.99 Input Voltage Window 990-5451K-001 17 Technical Data 480 V UPS System Inverter Short–Circuit Capabilities (Bypass not Available) IK1 – Short-Circuit between a Phase and Neutral 480 V IK1 S [kVA] Ik10ms [A] Normal operation /Battery operation Ik30ms [A] Normal operation /Battery operation Ik100ms [A] Normal operation /Battery operation Ik500ms [A] Normal operation /Battery operation Ik1s [A] Normal operation /Battery operation Ik5s [A] Normal operation /Battery operation I2 t total [A2s] Normal operation /Battery operation …

Maximum OCPD (A) Cable size per phase (AWG/kcmil) Copper / Aluminum EGC cable size (AWG/kcmil) … Recommended Bolt and Lug Sizes for Copper Cables Cable Size Terminal Bolt Diameter Cable Lug Type Crimping Tool Die … 990-5451K-001 52 Facility Planning 480 V UPS System Planning Clearance Clearance for UPSs with 1500 kW I/O Cabinet NOTE: Clearance dimensions are published for airflow and service access only. Consult with the local safety codes and standards for additional requirements in your local area. NOTE: The UPS system can be placed up against a wall and there is no requirement for rear or side access. Clearance for UPSs with 1500 kW I/O Cabinet NOTE: Clearance dimensions are published for airflow and service access only. Consult with the local safety codes and standards for additional requirements in your local area. NOTE: The UPS system can be placed up against a wall with no requirement for rear or side access. Front View 990-5451K-001 53 Facility Planning 480 V UPS System Guidance for Organizing Battery Cables NOTE: For 3rd party batteries, use only high rate batteries for UPS applications. NOTE: When the battery bank is placed remotely, the organizing of the cables is important to reduce voltage drop and inductance. The distance between the battery bank and the UPS must not exceed 200 m (656 ft). Contact Schneider Electric for installations with a longer distance. NOTE: To minimize the risk of electromagnetic radiation, it is highly recommended to follow the below guidance and to use grounded metallic tray supports. Cable Length 200 kW

Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities Introduction SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 5- eBus Depots EcoStruxure Value Proposition Applications Overview Reference Architectures 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories How does it work? Introduction to eBus Depots There are three main use cases recommended for the electrical installation, depending on the customer's needs: Use case 1: "Keep it simple, grid supply" Build and enable the electrical infrastructure to supply energy to the eBuses. Use case 2: "Self-consume, grid tied" Build and enable the electrical infrastructure while integrating the renewable energy sources. Manage energy sources for the eBuses, intended to optimize both technical and economic parameters. Use case 3: "Run off grid" Build electrical infrastructure with the ability to disconnect from the grid to help: • Increase availability (lack of supply from the grid) • Optimize energy supply prices • Enhance stability across the internal network ("microgrid") once disconnected from external energy sources. Public eBus Depot Use Cases Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities Introduction SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 5- eBus Depots EcoStruxure Value Proposition Applications Overview Reference Architectures 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories Main components of the electrical architecture Introduction to eBus Depots Public Main Components of the Electrical Architecture for eBus Depots Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories EcoStruxure Power Value Proposition Apps, analytics, and services Edge Control Connected products Fleet Management (Third party) for eBus Depots EV charger Circuit breaker Cloud-Based Advisor Services for Asset Management, EV Charging and distributed energy resources (renewables) Uninterruptible power supply Power meter Power quality solutions Panel server 2. Operational Management • Real-time monitoring and control of power system status and identification of abnormal temperature, insulation faults or power disturbances • EV Charging Expert to optimize the use of energy between every charging point • Microgrid Automation to manage Distributed Energy Resources (DERs) and improve real-time grid stability and reliability 3. Analysis & Optimization • Cloud-based predictive power asset maintenance with expert recommendation provided by our Schneider Electric service experts • Consulting services including network audits, microgrid sizing services, power systems engineering and sustainable energy procurement • Microgrid optimization using a cloud-based platform with necessary algorithms to get the most out of the local energy resources • EV advisor for advanced management of the charging process, connected to a route-planning application (third-party) 1. Primary Equipment • MV/LV range of power Connected Products for protection, power correction and monitoring • Battery Energy Storage Systems (BESSs) to improve grid flexibility and stability • High powered DC electric vehicle charging units AVEVA System Platform EcoStruxure Power Operation / Power Monitoring Expert EcoStruxure EV Charging Expert Simulation Engine EcoStruxure Microgrid Operation Our solution to control and supply energy to eBus depots Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Specific pillars for eBus depots EcoStruxure Power Value Proposition EcoStruxure Power provides applications to support the challenges of eBus depots for Railway and Urban Transportation, with the following pillars: Reliable Electrification Electrical Distribution Monitoring and Alarming Capacity Management Power Event Analysis Power Quality Monitoring, Correction, and Compliance Power Source and Load Control Safety and Comfort Enhance safety and comfort in passenger stations and tunnels Continuous Thermal Monitoring Guided Procedures Through Extended Reality Digitalization Operate centrally and maintain infrastructure efficiently Backup Power Testing Circuit Breaker Settings Monitoring Asset Performance Decarbonization Reduce energy consumption and carbon footprint Basic Energy Awareness Advanced Energy Performance Effective Energy Accounting Energy and Environmental Compliance Electrification (eBus Depot) Advanced Microgrid Improve reliability of electrical infrastructure Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Capacity Management è Visualize real-time or historical power system capacity è Monitor and trend circuit or equipment loading è Provide information for capacity planning Reliable Electrification Power Event Analysis è Provide a user-friendly graphical tool to simplify and save time in event analysis è Provide an aggregated view of events in the same dashboard è Enable root cause analysis Reliable Electrification Power Quality Monitoring, Correction, and Compliance è Power Quality Monitoring and Compliance: Monitor persistent steady state and event- based disturbances to better understand and analyze power quality disturbances è Power Quality Correction: Correct over/under voltages, harmonics, etc. Reliable Electrification Power Source and Load Control è Help isolate faults with relay automation and circuit breaker coordination è Help preserve critical loads by automatically transferring to alternate power è Help restore power quickly è Get real-time visibility, automation and control of the entire electrical infrastructure Reliable Electrification ■■■ ■■■ ■■■ ■■■ è Provide real-time status of the electrical distribution system è Help identify anomalies and notify the right personnel è Aggregate onboard alarm data in an easy-to-understand way è Take advantage of native integration of intelligent electrical devices Reliable Electrification Electrical Distribution Monitoring and Alarming ■■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Continuous Thermal Monitoring è Monitor the temperature of busbar, cable, transformer, and withdrawable circuit breaker connections è Help detect poor connections at an early stage è Provide temperature alarming and reporting for fast response Guided Procedures Through XR è Use Extended Reality to perform step-by-step guidance è Benefit from "X-ray" vision and virtually overlaid contextual asset and site information, live data, events and alarms è Take advantage of remote collaboration Safety and Comfort Safety and Comfort Backup Power Testing è Automatically record key backup power test parameters such as run time, engine loading, exhaust and engine temperatures è Perform automated backup power test reporting Digitalization Circuit Breaker Settings Monitoring è Compare current circuit breaker settings with commissioned settings è Help detect inappropriate setting modifications periodically è Provide information for capacity planning Digitalization Asset Performance è Make asset health visible across the entire system è Streamline inspections using continuous asset health monitoring è Optimize maintenance planning with analytics and expert advice Digitalization ■■■ ■■ ■■ ■ ■■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Effective Energy Accounting Identify areas for possible energy conservation measures: è Utility Bill Verification: Identify billing errors by comparison with a shadow bill è Cost Allocation: Allocate energy costs to terminals or departments for accurate billing è Power Factor correction: Mitigate harmonic effects and power quality issues Decarbonization Basic Energy Awareness è Energy Monitoring: Increase awareness of energy usage by creating easy-to- understand graphical dashboards and reports from data è Cost Allocation: Identify "quick-win" opportunities for energy savings Decarbonization è Energy Efficiency Compliance: Report effectively about local/global energy and environmental building code compliance è Greenhouse Gas Reporting: Track and report emissions effectively to help cut carbon emissions Decarbonization Energy and Environmental Compliance ■■ ■ ■ Advanced Microgrid è Enhance power system reliability, despite grid instability often resulting from powerful storms and grid unavailability è Reduce carbon emissions and optimize cost efficiency by leveraging Distributed Energy Resources (DERs) Decarbonization ■■ Advanced Energy Performance è Energy Performance: Normalize energy data (e.g. with respect to building area) to give context. Analyze energy performance in context using KPIs è Energy Benchmarking: Compare energy usage with respect to other comparable facilities è Energy Modeling and Verification: Model the energy usage versus energy drivers Decarbonization ■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable è Power the bus depot with an end-to-end electrical distribution solution for charging your electrical buses è Integrate and manage local power generation and batteries for self-consumption of renewable energy or for resiliency purposes Decarbonization Electrification (EV Charging for eBus Depot) ■■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Reference Electrical and Digital Architectures Typical electrical architecture Reference digital architecture Find the Schneider Electric products necessary to implement the selected applications. Then find their location in the electrical architecture. Find how the products, software solutions and cloud services are connected in the digital architecture. Public Typical Electrical Architecture for e-Bus Depots Public Reference Digital Architecture for e-Bus Depots Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities WHY READ THIS SECTION? SECTION 3 SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories The objective of this section is to: • Introduce tunnel systems • Review EcoStruxure Power value propositions and the associated applications for tunnel systems • Provide reference electrical and digital architectures EcoStruxure Power Digital Solutions and Services for: à Tunnel Systems Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories What is it? Introduction to Tunnel Systems Railway tunnels allow crossing of geographical landforms while respecting the layout limitations of the railway lines. They involve major civil engineering works and the supply of systems to improve the safe use of the infrastructure. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Access ControlVentilation How does it work? Introduction to Tunnel Systems A typical tunnel system consists of multiple technical systems that work in coordination in order to fulfill the operational plan. These include: Telecom Fire Detection Power Supply Drainage Lighting Weather Forecasting Signaling Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Main components of the electrical architecture Introduction Public Main Components of the Electrical Architecture for Tunnel Systems Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories EcoStruxure Power Value Proposition Apps, analytics, and services Edge Control Connected products for Tunnel Systems Cloud-Based Advisor Services for asset management, data integrity, and workforce empowerment with extended reality guidance AVEVA System Platform Protection relay Remote terminal unit Circuit breaker Safety control unit RIO drop Control unit Power quality meter Protection device UPS Power quality solutions Automatic transfer switch Variable speed drive Energy meter Panel server 2. Operational Management Edge Control for all systems such as elevators, escalators, lighting, HVAC, drainage, ventilation, etc. These systems can be: • Option 1: centrally controlled (from the Control Center) using Supervisory Control and Data Acquisition (SCADA) • Option 2: locally controlled using onsite HMIs or mobile apps A software interface is used to exchange the control perimeter between the local tunnel system and the Control Center. 3. Analysis & Optimization • Cloud-based predictive power asset maintenance with expert recommendation provided by our Schneider Electric service experts • Consulting Services including network and power quality audits • Augmented reality guidance for complicated or rarely performed procedures AVEVA System Platform EcoStruxure Power Operation / Power Monitoring Expert Cooling Local HMI Our solution to control and supply energy to tunnel systems 1. Primary Equipment Connected products include protective and electrical network automation devices, power meters, power conditioning units (UPS and power quality solution), and building automation. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Specific pillars for tunnel systems EcoStruxure Power Value Proposition EcoStruxure Power provides applications to support the challenges of tunnel systems for Railway and Urban Transportation, with the following pillars: Reliable Electrification Electrical Distribution Monitoring and Alarming Capacity Management Power Event Analysis Power Quality Monitoring, Correction, and Compliance Power Source and Load Control Safety and Comfort Enhance safety and comfort in passenger stations and tunnels Continuous Thermal Monitoring Guided Procedures Through Extended Reality Digitalization Operate centrally and maintain infrastructure efficiently Backup Power Testing Circuit Breaker Settings Monitoring Asset Performance Decarbonization Reduce energy consumption and carbon footprint Basic Energy Awareness Advanced Energy Performance Energy and Environmental Compliance Effective Energy Accounting Improve reliability of electrical infrastructure Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Capacity Management è Visualize real-time or historical power system capacity è Monitor and trend circuit or equipment loading è Provide information for capacity planning Reliable Electrification Power Event Analysis è Provide a user-friendly graphical tool to simplify and save time in event analysis è Provide an aggregated view of events in the same dashboard è Enable root cause analysis Reliable Electrification Power Quality Monitoring, Correction, and Compliance è Power Quality Monitoring and Compliance: Monitor persistent steady state and event- based disturbances to better understand and analyze power quality disturbances è Power Quality Correction: Correct over/under voltages, harmonics, etc. Reliable Electrification Power Source and Load Control è Help isolate faults with relay automation and circuit breaker coordination è Help preserve critical loads by automatically transferring to alternate power è Help restore power quickly è Get real-time visibility, automation and control of the entire electrical infrastructure Reliable Electrification ■■ ■■■ ■■■ ■■■ è Provide real-time status of the electrical distribution system è Help identify anomalies and notify the right personnel è Aggregate onboard alarm data in an easy-to-understand way è Take advantage of native integration of intelligent electrical devices Reliable Electrification Electrical Distribution Monitoring and Alarming ■■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Continuous Thermal Monitoring è Monitor the temperature of busbar, cable, transformer, and withdrawable circuit breaker connections è Help detect poor connections at an early stage è Provide temperature alarming and reporting for fast response Guided Procedures Through XR è Use Extended Reality to perform step-by-step guidance è Benefit from "X-ray" vision and virtually overlaid contextual asset and site information, live data, events and alarms è Take advantage of remote collaboration Safety and Comfort Safety and Comfort Backup Power Testing è Automatically record key backup power test parameters such as run time, engine loading, exhaust and engine temperatures è Perform automated backup power test reporting Digitalization Circuit Breaker Settings Monitoring è Compare current circuit breaker settings with commissioned settings è Help detect inappropriate setting modifications periodically è Provide information for capacity planning Digitalization Asset Performance è Make asset health visible across the entire system è Streamline inspections using continuous asset health monitoring è Optimize maintenance planning with analytics and expert advice Digitalization ■■■ ■■ ■■ ■ ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Effective Energy Accounting Identify areas for possible energy conservation measures: è Utility Bill Verification: Identify billing errors by comparison with a shadow bill è Cost Allocation: Allocate energy costs to terminals or departments for accurate billing è Power Factor correction: Mitigate harmonic effects and power quality issues Decarbonization Basic Energy Awareness è Energy Monitoring: Increase awareness of energy usage by creating easy-to- understand graphical dashboards and reports from data è Cost Allocation: Identify "quick-win" opportunities for energy savings Decarbonization è Energy Efficiency Compliance: Report effectively about local/global energy and environmental building code compliance è Greenhouse Gas Reporting: Track and report emissions effectively to help cut carbon emissions Decarbonization Energy and Environmental Compliance ■■■ ■■ ■■ Advanced Energy Performance è Energy Performance: Normalize energy data (e.g. with respect to building area) to give context. Analyze energy performance in context using KPIs è Energy Benchmarking: Compare energy usage with respect to other comparable facilities è Energy Modeling and Verification: Model the energy usage versus energy drivers Decarbonization ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Reference Electrical and Digital Architectures Typical electrical architecture Typical digital architecture Find the Schneider Electric products necessary to implement the selected applications. Then find their location in the electrical architecture. Find how the products, software solutions and cloud services are connected in the digital architecture. Public Typical Electrical Architecture for Tunnel Systems Public Reference Digital Architecture for Tunnel Systems Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities WHY READ THIS SECTION? SECTION 3 SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories The objective of this section is to: • Introduce depots and workshops • Review EcoStruxure Power value propositions and the associated applications for depots and workshops • Provide reference electrical and digital architectures EcoStruxure Power Digital Solutions and Services for: à Depots and Workshops Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories What is it? Introduction to Depots and Workshops A depot or workshop is a railway facility where preventive and corrective maintenance tasks are carried out on rolling stock. The difference between the two is not totally clear, but the former is usually more focused on train storage and their periodic maintenance, while the latter is more focused on major repairs. However, it is common for both types of services to be carried out within the same building. Main line Stabling Area Yard Area Pway & Infrastructure Building Workshop Building Car Delivery Test Track Depot Control Center Administrative Building 1 4 5 A train depot/workshop has the following main areas: 1. Train yard 2. Train workshop building 3. Train wash plant 4. Test track 5. Depot control center Wash Plant Wheel Lathe Store 2 3 Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Drainage Traction Power How does it work? Introduction to Depots and Workshops Typical depots and workshops consist of multiple technical systems that work in coordination in order to fulfill the operational plan. These include: Power Supply Microgrid Management Lighting Washing Maintenance Safety Process HVAC*Fire Detection * Heating, Ventilation, Air Conditioning Access Control Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Main components of the electrical architecture Introduction Public Main Components of the Electrical Architecture for Depots and Workshops Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our solution to control and supply energy to depots and workshops EcoStruxure Power Value Proposition Apps, analytics, and services Edge Control Connected products for Depots and Workshops Cloud-Based Advisor Services for asset management, data integrity, and workforce empowerment with extended reality guidance AVEVA System Platform Protection relay Remote terminal unit Circuit breaker Safety control unit Control unit Power quality meter Protection device UPS Power quality solutions Automatic transfer switch Variable speed drive Energy meter Panel server 2. Operational Management Edge Control for all systems such as depot power, traction power, lighting, HVAC, drainage, etc. These systems can be: • Option 1: centrally controlled (from the Control Center) using Supervisory Control and Data Acquisition (SCADA) • Option 2: locally controlled using onsite HMIs or mobile apps A software interface is used to exchange the control perimeter between the depot and the Control Center. 3. Analysis & Optimization • Cloud-based predictive power asset maintenance with expert recommendation provided by our Schneider Electric service experts • Consulting Services including network and power quality audits • Augmented reality guidance for complicated or rarely performed procedures AVEVA System Platform EcoStruxure Power Operation / Power Monitoring Expert Cooling Local HMI EcoStruxure Microgrid Operation Control Unit Drive controller 1. Primary Equipment Connected products include protective and electrical network automation devices, power meters, power conditioning units (UPS and power quality solution), and building automation. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Specific pillars for depots and workshops EcoStruxure Power Value Proposition EcoStruxure Power provides applications to support the challenges of depots and workshops for Railway and Urban Transportation, with the following pillars: Reliable Electrification Safety and Comfort Enhance safety and comfort in passenger stations and tunnels Digitalization Operate centrally and maintain infrastructure efficiently Decarbonization Reduce energy consumption and carbon footprint Capacity Management Guided Procedures Through Extended Reality Circuit Breaker Settings Monitoring Basic Energy Awareness Power Event Analysis Asset Performance Advanced Energy Performance Power Quality Monitoring, Correction, and Compliance Advanced Microgrid Electrical Distribution Monitoring and Alarming Continuous Thermal Monitoring Backup Power Testing Effective Energy Accounting Improve reliability of electrical infrastructure Overhead Line Protection and Automation Power Source and Load Control Energy and Environmental Compliance Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Capacity Management è Visualize real-time or historical power system capacity è Monitor and trend circuit or equipment loading è Provide information for capacity planning Reliable Electrification Power Event Analysis è Provide a user-friendly graphical tool to simplify and save time in event analysis è Provide an aggregated view of events in the same dashboard è Enable root cause analysis Reliable Electrification Power Quality Monitoring, Correction, and Compliance è Power Quality Monitoring and Compliance: Monitor persistent steady state and event- based disturbances to better understand and analyze power quality disturbances è Power Quality Correction: Correct over/under voltages, harmonics, etc. Reliable Electrification Power Source and Load Control è Help isolate faults with relay automation and circuit breaker coordination è Help preserve critical loads by automatically transferring to alternate power è Help restore power quickly è Get real-time visibility, automation and control of the entire electrical infrastructure Reliable Electrification ■■ ■■■ ■■■ ■■■ è Provide real-time status of the electrical distribution system è Help identify anomalies and notify the right personnel è Aggregate onboard alarm data in an easy-to-understand way è Take advantage of native integration of intelligent electrical devices Reliable Electrification Electrical Distribution Monitoring and Alarming ■■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Continuous Thermal Monitoring è Monitor the temperature of busbar, cable, transformer, and withdrawable circuit breaker connections è Help detect poor connections at an early stage è Provide temperature alarming and reporting for fast response Guided Procedures Through XR è Use Extended Reality to perform step-by-step guidance è Benefit from "X-ray" vision and virtually overlaid contextual asset and site information, live data, events and alarms è Take advantage of remote collaboration Safety and Comfort Safety and Comfort Backup Power Testing è Automatically record key backup power test parameters such as run time, engine loading, exhaust and engine temperatures è Perform automated backup power test reporting Digitalization Circuit Breaker Settings Monitoring è Compare current circuit breaker settings with commissioned settings è Help detect inappropriate setting modifications periodically è Provide information for capacity planning Digitalization ■■■ ■■ ■■ ■ è Provide distributed control and supervision of overhead (catenary) line disconnectors Reliable Electrification Overhead Line Protection and Automation ■■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Effective Energy Accounting Identify areas for possible energy conservation measures: è Utility Bill Verification: Identify billing errors by comparison with a shadow bill è Cost Allocation: Allocate energy costs to terminals or departments for accurate billing è Power Factor correction: Mitigate harmonic effects and power quality issues Decarbonization Basic Energy Awareness è Energy Monitoring: Increase awareness of energy usage by creating easy-to- understand graphical dashboards and reports from data è Cost Allocation: Identify "quick-win" opportunities for energy savings Decarbonization ■■■ ■■ Advanced Microgrid è Enhance power system reliability, despite grid instability often resulting from powerful storms and grid unavailability è Reduce carbon emissions and optimize cost efficiency by leveraging Distributed Energy Resources (DERs) Decarbonization ■■ Asset Performance è Make asset health visible across the entire system è Streamline inspections using continuous asset health monitoring è Optimize maintenance planning with analytics and expert advice Digitalization ■■ Advanced Energy Performance è Energy Performance: Normalize energy data (e.g. with respect to building area) to give context. Analyze energy performance in context using KPIs è Energy Benchmarking: Compare energy usage with respect to other comparable facilities è Energy Modeling and Verification: Model the energy usage versus energy drivers Decarbonization ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information è Energy Efficiency Compliance: Report effectively about local/global energy and environmental building code compliance è Greenhouse Gas Reporting: Track and report emissions effectively to help cut carbon emissions Decarbonization Energy and Environmental Compliance ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Reference Electrical and Digital Architectures Typical electrical architecture Typical digital architecture Find the Schneider Electric products necessary to implement the selected applications. Then find their location in the electrical architecture. Find how the products, software solutions and cloud services are connected in the digital architecture. Public Typical Electrical Architecture for for Depots and Workshops Public Typical Digital Architecture for Depots and Workshops Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities WHY READ THIS SECTION? SECTION 3 SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market The objective of this section is to: • Introduce the control center • Review EcoStruxure Power value propositions and the associated applications for the control center • Provide reference architectures EcoStruxure Power Digital Solutions and Services for: à Control Center Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories What is it? Introduction to the Control Center The Control Center is a central location from which the following facilities (described in the previous sections) are operated: • Traction Substations • Overhead Lines • Auxiliary Power System • Passenger Stations • Tunnel Systems • Datacenters Its purpose is to achieve compliance with the operational plan, with the minimum necessary resources. Comment: • Initially, the responsibility was located at the local levels of the facilities. • Now, process automation makes it possible to delegate responsibility to a higher hierarchy facility and increase the operational efficiency. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories Real-time Operation Asset Management Objective Add advanced facility maintenance strategies to traditional corrective and preventive maintenance. This helps optimize asset availability without increasing maintenance costs. Objective Optimize operations with the analytics applied to data acquired from the field devices. This helps to empower the workforce. Operational Efficiency How does it work? (1/2) Introduction to the Control Center The control center is the facility that centrally manages the railway installations. The most relevant element of this facility is the control room, from which the system operators are mandated to perform the following functions: How • Monitor and control the facilities including the implementation of automated systems that facilitate any changes in the configuration of the tasks. • Manage operations for all the facilities (full delegation, exceptions for abnormal situations). • Manage emergency scenarios for passenger stations and tunnel systems. Objective Manage the operational plan of the facilities remotely and centrally. This helps to optimize the state of operation under various situations. How Collect data from field devices to monitor asset health and perform: • Condition-based maintenance: Proactive monitoring depending on the condition of the asset. Maintenance is triggered when critical parameters vary beyond their "normal" range. • Predictive maintenance: a maintenance task is performed when measured variables of an asset deviate from those indicated as normal by a digital model of the asset. How Use data collected at operational level to implement advanced functionalities such as: • Electrical simulation: commonly used for operator training or operation support, and during the facility electrical design phase. • Basic and advanced reporting: advanced representation of information and generation of new data, using data processing techniques and AI models. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories A Redundancy-based Strategy The Control Center is responsible for the operations of all the facilities (except in abnormal situations mainly related to maintenance and telecom network issues). Therefore, it has a huge responsibility, and its availability is critical. To improve availability of the control center, essential services are usually implemented with redundancy: • Redundancy of the components inside the control center • Redundancy of the control center in other locations (emergency control center). How does it work? (2/2) Introduction to the Control Center In case of failure of a component or of unavailability of the control center, the redundant component / control center takes over the function/service until repair/availability. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories EcoStruxure Power Value Proposition Apps, analytics, and services Edge Control Connected products for Control Centers Cloud-Based Advisor Services for asset management, data integrity and workforce empowerment with extended reality guidance AVEVA Insight EcoStruxure XR Operator Advisor EcoStruxure EV Advisor EcoStruxure Microgrid Advisor EcoStruxure Building Advisor AVEVA System Platform EcoStruxure Power Operation / Power Monitoring Expert EcoStruxure Building Operation Simulation Engine EcoCare Membership * EcoStruxure Cybersecurity Admin Expert 2. Operational Management Among the usual tasks to be carried out by the operators of the control center, we can highlight the following: • Assurance of power supply to trains and rail consumers • Mitigation of the impact of electrical faults in the railway traction scope. • Implementation of the different operational / emergency scenarios defined for passenger stations and tunnels. • Central management of the cybersecurity for the full architecture. 3. Analysis & Optimization Applications for advanced asset management, analysis and optimization of operations: • Predictive and condition-based maintenance for electrical assets • Integration, contextualization, analysis, and representation of information • Advanced management of microgrids and electric chargers, including technical and economic aspects. • Consulting Services, including network and power quality audits • Augmented reality guidance for complicated or rarely performed procedures 1. Primary Equipment Data provided by connected products from the different facilities Energy control of traction, non-traction and catenary systems Passenger Stations Tunnels Our solution to control and supply energy to control centers Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Specific pillars for control centers EcoStruxure Power Value Proposition EcoStruxure Power provides applications to support the challenges of control centers for Railway and Urban Transportation, with the following pillars: Reliable Electrification Improve reliability of electrical infrastructure Electrical Distribution Monitoring and Alarming Capacity Management Power Event Analysis Power Quality Monitoring, Correction, and Compliance Overhead Line Protection and Automation Safety and Comfort Enhance safety and comfort in passenger stations and tunnels Continuous Thermal Monitoring Guided Procedures Through Extended Reality Digitalization Operate centrally and maintain infrastructure efficiently Circuit Breaker Settings Monitoring Asset Performance Operator Training Simulation Simulate Before Operate Cybersecurity Central Management Asset Preventive Maintenance Asset analytics Massive Data Archive and Contextualization Rail Power Design Decarbonization Reduce energy consumption and carbon footprint Basic Energy Awareness Advanced Energy Performance Energy and Environmental Compliance Electrification (EV Charging for eBus Depot) Building Automation Effective Energy Accounting Advanced Microgrid Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Capacity Management è Visualize real-time or historical power system capacity è Monitor and trend circuit or equipment loading è Provide information for capacity planning Reliable Electrification Power Event Analysis è Provide a user-friendly graphical tool to simplify and save time in event analysis è Provide an aggregated view of events in the same dashboard è Enable root cause analysis Reliable Electrification Power Quality Monitoring, Correction, and Compliance è Power Quality Monitoring and Compliance: Monitor persistent steady state and event- based disturbances to better understand and analyze power quality disturbances è Power Quality Correction: Correct over/under voltages, harmonics, etc. Reliable Electrification ■■■ ■■■ ■■ è Provide real-time status of the electrical distribution system è Help identify anomalies and notify the right personnel è Aggregate onboard alarm data in an easy-to-understand way è Take advantage of native integration of intelligent electrical devices Reliable Electrification Electrical Distribution Monitoring and Alarming ■■■ è Provide distributed control and supervision of overhead (catenary) line disconnectors Reliable Electrification Overhead Line Protection and Automation ■■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Continuous Thermal Monitoring è Monitor the temperature of busbar, cable, transformer, and withdrawable circuit breaker connections è Help detect poor connections at an early stage è Provide temperature alarming and reporting for fast response Guided Procedures Through XR è Use Extended Reality to perform step-by-step guidance è Benefit from "X-ray" vision and virtually overlaid contextual asset and site information, live data, events and alarms è Take advantage of remote collaboration Safety and Comfort Safety and Comfort Circuit Breaker Settings Monitoring è Compare current circuit breaker settings with commissioned settings è Help detect inappropriate setting modifications periodically è Provide information for capacity planning Digitalization Asset Performance è Make asset health visible across the entire system è Streamline inspections using continuous asset health monitoring è Optimize maintenance planning with analytics and expert advice Digitalization ■■■ ■ ■ ■■ Operator Training Simulation è Train new employees and build confidence on new systems è Practice operation within a simulated but highly realistic environment to enhance safety and operational efficiency è Track and review trainee actions to analyze and challenge them Digitalization ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Simulate Before Operate è Provide operators with a list of potential side effects, prior to executing a command è Empower employees to feel more confident when operating their facilities by providing real-time guidance è Reduce human error that could lead to outages or safety concerns Digitalization Cybersecurity Central Management è Integrate cybersecurity solutions allowing the operations team to have visibility of key cybersecurity data è Help manage/maintain cybersecurity control points è Align to cybersecurity standards and best practices to strengthen OT security Digitalization Asset Preventive Maintenance è Minimize inventory costs and improve spare part availability è Manage mobile work for more accurate and timely data collection è Receive proactive maintenance information by identifying labor/material/tools/drawings on work order Digitalization Asset Analytics è Analyze utilization, efficiency, and condition-management of assets. Receive alerts and notifications è Provide automated analytics using supervised or unsupervised machine learning è Create dynamic data visualizations and asset frameworks for contextual data viewing Digitalization Massive Data Archive and Contextualization è Collect and store in one single place real-time data from operating assets with sub- second granularity è Contextualize and visualize data Digitalization ■■ ■■■ ■■ ■■ ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Rail Power Design è Visualize and analyze traction power systems using synchronized geospatial and schematic

views è Simulate and analyze operation of combined DC and AC power supply networks è Model traction power-specific devices with built-in components and engineering libraries Digitalization Effective Energy Accounting Identify areas for possible energy conservation measures: è Utility Bill Verification: Identify billing errors by comparison with a shadow bill è Cost Allocation: Allocate energy costs to terminals or departments for accurate billing è Power Factor correction: Mitigate harmonic effects and power quality issues Decarbonization Basic Energy Awareness è Energy Monitoring: Increase awareness of energy usage by creating easy-to- understand graphical dashboards and reports from data è Cost Allocation: Identify "quick-win" opportunities for energy savings Decarbonization Advanced Microgrid è Enhance power system reliability, despite grid instability often resulting from powerful storms and grid unavailability è Reduce carbon emissions and optimize cost efficiency by leveraging Distributed Energy Resources (DERs) Decarbonization ■■■ ■■ ■■ ■■ Advanced Energy Performance è Energy Performance: Normalize energy data (e.g. with respect to building area) to give context. Analyze energy performance in context using KPIs è Energy Benchmarking: Compare energy usage with respect to other comparable facilities è Energy Modeling and Verification: Model the energy usage versus energy drivers Decarbonization ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information è Energy Efficiency Compliance: Report effectively about local/global energy and environmental building code compliance è Greenhouse Gas Reporting: Track and report emissions effectively to help cut carbon emissions Decarbonization Energy and Environmental Compliance è Power the bus depot with an end-to-end electrical distribution solution for charging your electrical buses è Integrate and manage local power generation and batteries for self-consumption of renewable energy or for resiliency purposes Decarbonization Building Automation è Monitor and control the electromechanical systems present in the passenger station è Automate processes within the passenger station è Implement operational and emergency scenarios Decarbonization Electrification (EV Charging for eBus Depot) ■■■ ■■ ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Reference Electrical and Digital Architectures Typical reference architecture Typical digital architecture Find the Schneider Electric digital solutions and services relevant to implement the selected applications. Then find their location in the reference architecture. Find how the products, software solutions and cloud services are connected in the digital architecture. Public Typical Reference Architecture for the Control Center Public Reference Digital Architecture for the Control Center Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Communications Protocols Time Synchronization Integration with BMS Cybersecurity Environmental Data Program BIBLIOGRAPHY SECTION 5 – Customer Stories WHY READ THIS SECTION? Design Considerations à Control Center Solutions à Communication Protocols à Time Synchronization à Integration with BMS à Cybersecurity à Environmental Data Program The objective of this section is to: • Provide the details of the critical system design components to be considered while designing digital architecture • Addresses design considerations of the electrical installation in the context of communications, data, time and cybersecurity à Control Strategies for Passenger Stations à Control Strategies for Traction substations Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Communications Protocols Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program The control center centralizes the operation of railway facilities. Schneider Electric offers the following solutions for effective management and control: How to Choose a Solution for Operation Control Centers Management of Energy Management of Passenger Stations Control of Railway Tunnels Control of Datacenters AVEVA System Platform EcoStruxure Power Monitoring Expert EcoStruxure Building Operation EcoStruxure IT Expert AVEVA System Platform AVEVA System Platform Basic functionalities EcoStruxure Power Operation Complex systems Building approach Industrial approach Additional analysis EcoStruxure Power Monitoring Expert • Continuous thermal monitoring • Power event analysis • Power quality monitoring • Energy usage analysis • Energy efficiency & power quality compliance • Good capabilities for integration with external systems • Industrial interoperability protocols • Management of power supply • Monitoring of environmental conditions • Railways • Building element integration • Building management • Interoperability protocols • Urban Transportation • Higher integration needs of external systems • Industrial interoperability protocols • Basic operation and monitoring • Alarm management • Access control • Automatism and interlocks • Basic reporting • Continuous thermal monitoring • Power event analysis • Power quality monitoring • Energy usage analysis • Energy efficiency & power quality compliance • Advanced alarm management • Advanced reporting & data analytics tools • Emergency control center • Graphical event replay • Scalability Additional analysis EcoStruxure Power Monitoring Expert • Continuous thermal monitoring • Power event analysis • Power quality monitoring • Energy usage analysis • Energy efficiency & power quality compliance Tunnel Management Additional analysis EcoStruxure Power Monitoring Expert • Continuous thermal monitoring • Power event analysis • Power quality monitoring • Energy usage analysis • Energy efficiency & power quality compliance Datacenter Management Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Control Strategies for Passenger Stations Passenger stations can be conceptualized in various ways, depending on the approach to automation and the perception of the facility. Surface-installed passenger station Underground passenger station Application • Mainlines or in high-speed rail systems Control strategy • Considered as a specialized type of building • Alignment with building management system Typical equipment • Floor controllers (AS-P) • Room controllers (RP-C) • Building Operation & Building Advisor for centralizing station information. Telecommunication Protocols • KNX • DALI • Other standard telecontrol protocols. Application • Urban transportation Control strategy • Considered as an industrial facility • Use of industrial automation for critical components like ventilation Typical equipment • PLCs based solutions (M580 and M340) • AVEVA System Platform for centralizing information Telecommunication Protocols • OPC (for advanced data modeling and cybersecurity features). • Modbus (for interconnection with legacy systems) Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Control Strategies for Traction Substations Alternating Current (AC) Direct Current (DC) Application Mainly in high performance systems such as mainlines or in high- speed rail systems • Railway systems with very high energy demand • High-speed travel • Railway systems with a very high frequency of train movements Control Strategy • Use elements borrowed from electrical distribution Typical equipment • Specialized controllers for managing electrical devices with a native implementation of most of the necessary functions for substation automation Interoperability standard • IEC 61850: describes the implementation of the functions present in a substation from both a constructive and functional perspective Advantage • Fully adapted to control an electrical process • Analysis of electrical events • Excellent performance • Maintenance management & engineering tools • Good interoperability due to the use of IEC 61850 • Cybersecurity requirements Drawback • Higher price Application Mainly urban transportation • Systems with lower energy demand (tramways) • Networks with a strong tradition in this technology (metros) Control Strategy • Choose a general-purpose programmable logic controller (PLC) as the main element for their automation Typical equipment • Use general-purpose programmable logic controllers (PLCs) for automation Interoperability standard • Modbus (and variants) Advantage • Simple configuration • Price competitive Drawback • Limitation in meeting usual standards of the electrical world • Limited performance • Limitations due to Modbus: deficiencies in electrical object modeling, event dating, and cybersecurity. Can be addressed using non-standard versions of the protocol or OPC UA protocol (widely used in industrial environments). Control strategy is different whether the system is supplied with alternating or direct current: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Communications Protocols Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Modern electrical distribution systems, especially in critical infrastructure like railways and urban transportation, use various industrial protocols for data communication from devices such as circuit breakers, relays, controllers, and sensors. Key protocols include: Commonly used for high-speed medium voltage automation. Provides: • Consistent measurement naming • Fast device-to-device communication (GOOSE messaging) • Communication to a SCADA system IEC 61850 Modbus RTU and Modbus TCP/IP Common in low voltage systems for metering, protection, and control. Can convert serial Modbus to Modbus TCP/ IP for data integration with a power monitoring or SCADA software . Wireless (IEC 802.15-4, e.g. Zigbee) Enables low-powered simple data communication for energy and condition monitoring sensors. Can be aggregated and converted to Modbus TCP/IP for integration with a power monitoring or SCADA software (using a data concentrator and protocol converter device) EcoStruxure Power natively integrates with Schneider Electric devices to obtain real-time, historical event and data logs, as well as waveforms. However, it is common for 3rd party devices to store event logs and waveform data in proprietary formats. The EcoStruxure Power platform can acquire data from any device using the open protocols mentioned above, provided the data is available in non-vendor-proprietary formats. • Communications Learn more about: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Time Synchronization Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Environmental Data Program Communications Protocols Time Synchronization Why consider time synchronization of connected products? To operate, EcoStruxure Power applications collect data from the connected products of the electrical installation (such as relays, trip units, power meter, sensors). When applications analyze and correlate timestamped data from multiple connected products, it is crucial to make sure that their internal clocks are accurate relative to other devices and local time. The setting of devices to a single time reference is called time synchronization. The choice of the time synchronization solution must be defined during the system design phase. It depends on the time criticality of the applications deployed to monitor and control the different parts of the installation. Refer to next page for further explanations about time criticality. • "How to Optimize Time-Synchronization and Data Recording for EcoStruxure Power Digital Applications" Technical Guide For a detailed coverage of time synchronization, refer to: • Data recording and Timestamping section in the EcoStruxure Power Design Guide Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Time Synchronization Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Environmental Data Program Communications Protocols What is the time criticality of an application? Time Synchronization The time criticality of an application defines the level of time accuracy required for data timestamping to enable the proper operation of the application. EcoStruxure Power categorizes applications into three levels of time criticality: Example of time criticality: • Continuous Thermal Monitoring: This application monitors the progressive rise in busbar connection temperature to help prevent fires. It has a low time criticality. • Power Event Analysis: This application reconstructs the sequence of events among multiple electrical equipment to help understand the cause(s) of an incident. It has a high time criticality. Refer to next page to learn how to select the appropriate time synchronization solution based on the time criticality. • Time criticality of applications Learn more about: Digital Application Time Critical Time Accuracy Upper Limit Time Accuracy Lower Limit High ± 1 ms ± 10 ms Medium ± 10 ms ± 1 s Low ± 1 s ± 10 s Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Time Synchronization Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Environmental Data Program Communications Protocols How to select the time synchronization solution based on time criticality? Time Synchronization There are many options available for time synchronization protocols, which can make it challenging to develop a cohesive strategy for all connected devices. To achieve optimal performance while minimizing costs, it is common to enforce the most accurate protocols only in the sensitive areas of electrical distribution (e.g., the electrical supply of core industrial processes) and use less accurate solutions in areas with lower sensitivity (e.g., utilities). The table below provides an overview of the solutions based on achieved time criticality and related costs: To summarize the table : • PTP provides the best performance versus cost option available today for highly time-critical applications, but is not available on all devices • IRIG-B offers similar performance to PTP but comes with a much higher installation cost. • NTP is the next best alternative for medium time-criticality needs. • SNTP or Modbus are adequate for low time-critical applications. Application Time Critical Typical Time Accuracy Protocol Media Protocol Typical Cost High ± 1 ms Ethernet PTP (IEEE 1588) $ $ High ± 1 ms Serial IRIG-B $ $ $ Medium ± 10 ms to 100 ms Ethernet NTP $ Medium ± 100 ms Serial DCF77 $ $ Low ± 1 s Ethernet SNTP $ Low ± 1 s Ethernet Over Modbus / ION from Edge Control $ Low ± 1 s Serial 1 per 10 $ $ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Integration with BMS Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Time Synchronization Environmental Data Program Communications Protocols Why integrate mechanical and electrical systems? Integration with Building Automation Systems (BMS) • Data Integration and Interoperability between Systems Learn more about: Need for data aggregation Facility infrastructure is experiencing a convergence of information and operational systems. This is particularly true for Railway and Urban Transportation applications, where mechanical and electrical systems are essential infrastructure. These systems are rapidly generating increasing amounts of data, with the addition of new sensors, meters, and other smart equipment. It is crucial to have robust software system with proper data aggregation from these devices. Examples of mechanical and electrical systems integration in Railway • Energy performance monitoring : Track and model facility energy usage; • Asset management: View mechanical and electrical asset performance in one place; • Fault management: Detect faults and respond through an integrated interface. Benefits of systems integration Integrating the systems: • Creates a unified interface for visualizing, analyzing, and reporting data, simplifying daily tasks for operations and maintenance staff; • Enables applications to utilize context from both systems to optimize the decision-making processes; • Enhances overall Operational efficiency Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Integration with BMS Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Time Synchronization Environmental Data Program Communications Protocols Why plan the integration at the design phase? Integration with Building Automation Systems (BMS) • Data Integration and Interoperability between Systems Learn more about: Costly retrofit of existing installations Traditionally, Power Management Systems (electrical systems) and Building Management Systems (including mechanical systems) are designed in silos. The consequence is that it leaves the end user with little to no electrical data in operational systems. Retrofitting this into an existing system can be quite costly. Therefore, it is essential to design the proper IoT electrical systems far in advance. Advantages of early system integration Enabling the BMS and PMS to integrate directly to relevant data allows the systems to perform as designed. Additionally, it also: • Reduces cost and complexity by minimizing excessive wiring of electrical devices to mechanical control systems. • Helps system integrators by enabling a seamless interface to manage facility operations and maintenance; Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Integration with BMS Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Time Synchronization Environmental Data Program Communications Protocols How is data acquired and integrated within the architecture? (1/2) Integration with Building Automation Systems (BMS) Data acquisition Digital electrical monitoring and control software acquires data from intelligent electrical devices via open communication protocols. This includes: • Real-time information • Historical power events • Data logs • Electrical signal waveforms • Service diagnostics. By default, BMS (Building Management Systems) cannot retrieve certain data from the electrical distribution, such as event logs, waveforms, and diagnostic data. Trying to do this directly with the BMS would require a tremendous amount of engineering. It is more efficient and native to let a PMS (Power Management System) collect the data from the electrical distribution and then integrate the PMS with the BMS. • Data Integration and Interoperability between Systems Learn more about: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Integration with BMS Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Time Synchronization Environmental Data Program Communications Protocols How is data acquired and integrated within the architecture? (2/2) Integration with Building Automation Systems (BMS) Data Integration The method/tool to integrate the data depends on the data type, and on the direction of the transfer: The integration is performed through: • An Extract Transform Load functions Used for historical building management data to enable energy data correlation. The integration is performed through: • EcoStruxure Web Services Used for real-time data, alarms, and historical data • Web interface integration (Single Sign On) Used for power and energy dashboards, graphical diagrams, trends, reports, and configuration pages EcoStruxure Building Operation (EBO) EcoStruxure Power Operation (EPO) with Advanced Reporting and Dashboards EcoStruxure Building Operation (EBO) EcoStruxure Power Operation (EPO) with Advanced Reporting and Dashboards PublicExample of Combined Solution with EcoStruxure Building Operation and EcoStruxure Power Operation with Advanced Reporting and Dashboards Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols ACCESS CONTROL Seven pillars to strengthen cybersecurity Cybersecurity Protect electrical components by verifying the identity of any user requesting access to a component before activating the communication with that component. When used in conjunction with security event logging, this will include ensuring 'non-repudiation', for example, a person cannot deny that they performed a particular action. Access Control DATA CONFIDENTIALITY USE CONTROL DATA FLOW TIMELY RESPONSE TO EVENTS RESOURCE AVAILABILITY Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Protect against unauthorized actions on component resources by verifying that the necessary privileges have been granted before allowing a user to perform the actions. This must address what a hacker can potentially do if they access the system and counteract that by only giving the minimum level of access necessary for that user to perform their role. Use Control USE CONTROL DATA CONFIDENTIALITY DATA INTEGRITY DATA FLOW TIMELY RESPONSE TO EVENTS RESOURCE AVAILABILITY ACCESS CONTROL Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Ensure that the components will perform as intended during operational and non-operational states, such as energy production and storage, or a maintenance shutdown. Consider a Circuit Breaker that is detecting potential issues in its operation: if the SCADA system is hacked and is forced to indicate everything is okay, that could cause an unexpected and dangerous event. Data Integrity DATA INTEGRITY DATA CONFIDENTIALITY USE CONTROL DATA FLOW TIMELY RESPONSE TO EVENTS RESOURCE AVAILABILITY ACCESS CONTROL Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Protection of component-generated confidential or sensitive nature information, whether at rest or in transit. Also, protection of data to avoid hackers who aim to break in. Data regarding energy profiles and usage could provide information into confidential Railway operations. Data Confidentiality DATA CONFIDENTIALITY USE CONTROL DATA INTEGRITY DATA FLOW TIMELY RESPONSE TO EVENTS RESOURCE AVAILABILITY ACCESS CONTROL Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Ensure the connection of the device to a segmented network where disconnection strategy, unidirectional gateway, firewall, and demilitarized zones are defined to avoid unnecessary data flow. Network segmentation is a strategy that can stop a cyberattack from going from one connected system to another (for example, from the electrical communication network to the business network). Data Flow DATA FLOW DATA CONFIDENTIALITY USE CONTROL DATA INTEGRITY TIMELY RESPONSE TO EVENTS RESOURCE AVAILABILITY ACCESS CONTROL Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Detect, identify and respond to security violations by notifying the proper authority, reporting needed evidence of the violation, and taking timely corrective action when incidents are discovered in mission- critical or safety-critical situations. Timely Response to Events TIMELY RESPONSE TO EVENTS DATA CONFIDENTIALITY USE CONTROL DATA INTEGRITY DATA FLOW RESOURCE AVAILABILITY ACCESS CONTROL Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Ensure the availability of the application or device against the degradation or denial of essential services. Resource Availability RESOURCE AVAILABILITY DATA CONFIDENTIALITY USE CONTROL DATA INTEGRITY DATA FLOW TIMELY RESPONSE TO EVENTS ACCESS CONTROL Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Recommendations for selecting your partners for an optimal cybersecurity journey Cybersecurity The IEC 62443 standard provides essential guidelines for enhancing the security of connected electrical distribution systems, including network, control, and safety solutions. When selecting partners, it is important that they understand the standard well and implement it effectively. It's crucial to choose a partner with robust internal processes who can certify that products and solutions are developed according to well-defined procedures. At Schneider Electric, we have dedicated services to support throughout the cybersecurity journey. SOLUTION PROVIDERS SERVICE PROVIDERS CONSULTANT Find an electrical power distribution specialist with a deep understanding of cybersecurity requirements. They should: • Help you with the risk assessment; • Define the levels of security you require, compliant with IEC 62443; • Provide guidance on implementing best practices for cybersecurity. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Recommendations for selecting your partners for an optimal cybersecurity journey Cybersecurity The IEC 62443 standard provides essential guidelines for enhancing the security of connected electrical distribution systems, including network, control, and safety solutions. When selecting partners, it is important that they understand the standard well and implement it effectively. It's crucial to choose a partner with robust internal processes who can certify that products and solutions are developed according to well-defined procedures. At Schneider Electric, we have dedicated services to support throughout the cybersecurity journey. CONSULTANT SERVICE PROVIDERS SOLUTION PROVIDERS Choose an electrical system technology provider that has adopted the IEC 62443 standard and has a secure development lifecycle process in place that: • Ensures systems are resilient in case of cyberattack; • Provides a formal process to inform and assist customers if any security vulnerabilities are discovered; • Fully tests and validates the security of all components and systems; • Demonstrates third-party cybersecurity certification; • Delivers customized and flexible solutions that align with your business requirements. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Recommendations for selecting your partners for an optimal cybersecurity journey Cybersecurity The IEC 62443 standard provides essential guidelines for enhancing the security of connected electrical distribution systems, including network, control, and safety solutions. When selecting partners, it is important that they understand the standard well and implement it effectively. It's crucial to choose a partner with robust internal processes who can certify that products and solutions are developed according to well-defined procedures. At Schneider Electric, we have dedicated services to support throughout the cybersecurity journey. CONSULTANT SOLUTION PROVIDERS SERVICE PROVIDERS Choose partners with the required capabilities: • A system integrator with deep IT and OT experience including cybersecurity within the context of critical operational systems • Cybersecurity services that can deliver quick response to help assess and recover from a cyberattack. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Certified secure system architecture according to IEC 62443-3-3 with documented processes and solutions for a secure system. Cybersecurity system configuration software for consistent security policy deployment. Consulting services from design, implementation, operations and maintenance to tailor your security solutions to your strategy and budget. Our solutions to support cybersecurity journey Cybersecurity At Schneider Electric, we can: • Provide a selection of cybersecurity certified products • Provide certified system architectures and solutions • Deliver lifecycle services Lifecycle servicesCertified products Certified systems & solutions • Cybersecurity Learn more about: Certified products developed according to IEC 62443 functional requirements with Secure Development Lifecycle processes. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Time Synchronization Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Communications Protocols Environmental Data Program Governments are committing to carbon neutrality by 2050, leading to new regulations promoting sustainability: ESG reporting is becoming crucial. The Corporate Sustainability Reporting Directive (CSRD) expands disclosure requirements to nearly 50,000 companies, including those outside the EU. This enhances transparency and accountability. Consumers demand sustainable practices, with a rise in repairing, reselling, and reusing products. However, greenwashing remains a challenge, as some companies make unsubstantiated sustainability claims. Regulators are cracking down on false claims, emphasizing the need for credible and verifiable environmental data. Consumer Expectations and Greenwashing Risks The need to address ESG regulations (ESG = Environmental, Social, and Governance) At Schneider Electric, we have deployed an Environmental Data Program to address this need. Discover more next page Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Time Synchronization Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Communications Protocols Next-level transparency for better-informed product choices Environmental Data Program The Environmental Data Program is a framework for how we, at Schneider Electric, measure, categorize, and compare the environmental attributes and footprint of our products. Using a rigorous, fact-based methodology, the program provides environmental data from across the product lifecycle. Use Better: How sustainable a product is, including environmental footprint, materials and substances, packaging, and energy efficiency. Use Longer: How a product's lifetime can be effectively extended in terms of repairability and updatability. Use Again: How a product can be reused, from dismantling and remanufacturing to recyclability and manufacturer take back. With this transparent, fact-based data, customers and partners are empowered to make conscious environmental choices and accurately evaluate and report on sustainability performance. All our hardware offers have an associated environmental data available on se.com product pages. • Schneider Electric Environmental Program Learn more about: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 5 – Customer Stories Railway: Europe Urban Transportation: US SECTION 3 – Digital Solutions and Services across the Facilities SECTION 5 SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center SECTION 4 – Design Considerations 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market WHY READ THIS SECTION? BIBLIOGRAPHY Urban Transportation: Europe Customer Stories The objective of this section is to: • Showcase our solutions provided across globe in the Railway and Urban Transportation sectors, addressing our customers' challenges and key needs. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 5 – Customer Stories SECTION 4 – Design Considerations Railway: Europe Urban Transportation: US SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market BIBLIOGRAPHY Urban Transportation: Europe Solution Provided Railway: A Leading Railway Operator in Europe Manage and operate efficiently a country-wide network: • Nearly 6.000 km mainlines railway network with almost 340 electrical substations; • Nearly 4.000 km of reliable high speed national rail network with almost 175 traction electrical facilities. Services • Maintenance services: corrective and preventive • Engineering and electrical substation design • Cybersecurity Edge Control • AVEVA System Platform for energy and building management at Control Center level • EcoStruxure Power Automation System as the substation automation solution • EcoStruxure Power Monitoring Expert for power management with Power Quality improvements Connected products • AC MV Panels for traction network: 25 kV AC high speed and 3.3 kV DC mainlines • Cabinets for auxiliary power line • Overhead line disconnectors (OHL): 25 kV AC high speed and 3.3 kV DC mainlines • PowerLogic T500 (formerly Saitel) for data acquisition and concentration • Building Management System for Passenger Stations • Tunnel Automation System Customer Challenges • Real-time single view of the national rail network, through integrated main and back-up control centers • Optimized energy through integrated monitoring and energy management systems Customer Benefits Public Solution Provided for a Leading Railway Operator in Europe Apps, analytics, and services Edge Control Connected products AVEVA System Platform EcoStruxure Power Monitoring Expert EcoStruxure Power Automation System Cybersecurity Consulting Digitalization Consulting Electrical Engineering Maintenance Services Commissioning and Training MV switchgear, control units, protection relays, power meters, overhead line controllers Note: Pictures displayed here may not represent the actual product available on site. They are used for pictorial demonstration only. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 5 – Customer Stories Railway: Europe Urban Transportation: US SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market SECTION 4 – Design Considerations BIBLIOGRAPHY Urban Transportation: Europe Customer Challenges Urban Transportation: Brookville Smart Energy Bus Depot in US • Electrification Converting municipal bus fleet to electric • Resilience Extreme weather and extended past power outages • Sustainability GHG reduction targets of 80% by 2027 and 100% by 2035 Services • EcoStruxure Microgrid Advisor implementing: - Tariff Management, - Self-consumption - Demand charge reduction • EcoStruxure Power Advisor for power management with Power Quality improvements Edge Control • EcoStruxure Power Operation for power management • Load Management System for optimizing the charging process from technical and economical point of view • EcoStruxure Microgrid Operation to integrate removable energy and manage the potential islanded situation from the grid Connected products • EV Charger as main charging element to provide energy to the bus fleet • Battery Storage System to store energy and help in the optimization of the charging process • Energy Control Center, integrating all LV equipment needed Solution Provided Watch now Customer Benefits • 44 buses transitioning from diesel to electric, and powered by on-site low-carbon energy • 62% of reduced lifetime emissions expected from the microgrid (equivalent to 155,000 tons of GHG) • 99.9% resilience and reliability of operations, sized to handle peak demand Customer Benefits Public Solution Provided for Brookville Smart Energy Bus Depot in the US Apps, analytics, and services Edge Control Connected products Energy Control Center Battery Storage System EV Charger Charge Pilot Controller EcoStruxure Microgrid Operation Load Management System EcoStruxure Power Advisor EcoStruxure Microgrid Advisor Note: Pictures displayed here may not represent the actual product available on site. They are used for pictorial demonstration only. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 5 – Customer Stories Railway: Europe SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market SECTION 4 – Design Considerations Urban Transportation: US BIBLIOGRAPHY Urban Transportation: Europe Customer Challenges Solution Provided Urban Transportation: A Leading Metro Operator in Europe Services • ETAP eTraX Simulation Engine for: - Modeling, design, analysis - Predictive simulation of power networks - Operator training simulation (OTS) Edge Control • AVEVA System Platform to operate energy systems and passenger stations from the control center level • Modicon M580 to automate energy systems and passenger stations Connected products • MV panel solutions: RM6 and SM AirSeT • PowerLogic P5 to implement electrical protection functions • Modicon M380 to implement basic automation and information acquisition Customer Benefits • Centralize view for informed decision-making in energy management and passenger stations. • Improve safety and operational efficiency with end-to-end visibility across facilities. • Facilitate seamless integration with legacy and modern systems. Customer Challenges • Improvement of operational efficiency with new extended remote operation capabilities. • Open platform integrating multiple external systems with many certified system integrators. • Enhanced modeling, design, analysis, operation planning, predictive simulation and automation services enabled by ETAP real-time solution. Customer Benefits Public Solution Provided for Leading Metro Operator in Europe Apps, analytics, and services Edge Control Connected products Simulation Engine Modicon M580 SM AirSeT RM6 (SeT series) LV Switchgear EcoStruxure Power Automation System PowerLogic P5 Modicon M340 Note: Pictures displayed here may not represent the actual product available on site. They are used for pictorial demonstration only. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities BIBLIOGRAPHY Reference Document Useful Links BIBLIOGRAPHY SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center SECTION 4 – Design Considerations SECTION 5 – Customer Stories 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities BIBLIOGRAPHY SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center SECTION 4 – Design Considerations SECTION 5 – Customer Stories 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Useful Links Design Guide Reference Documents Digital Applications for Large Buildings and Critical Facilities The Digital Applications Design Guide provides comprehensive details on the building blocks of EcoStruxure Power: the IoT applications are driven by a software layer to control the traditional electrical distribution infrastructure. Developed to help engineering consultants and designers, this guide is an invaluable resource for specifying, designing and prescribing EcoStruxure Power architectures capable of performing one or more of the business-driven applications described within. Access the Design Guide online from the Landing page (IEC/NEMA) Download the PDF View online Download IEC Download NEMA Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities Reference Document Useful Links BIBLIOGRAPHY SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center SECTION 4 – Design Considerations SECTION 5 – Customer Stories 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Transportation landing page on se.com Useful links Landing page Public Schneider Electric Industries SAS 35, rue Joseph Monier CS 30323 92506 Rueil Malmaison Cedex France www.se.com © 2025 Schneider Electric. All Rights Reserved. All trademarks are owned by Schneider Electric SE, its subsidiaries and affiliated companies. All other brands are trademarks of their respective owners 2025/01/23 ESXP2RG004EN eConversion Premium protection and sustainability for highly critical applications A unique high-efficiency mode available for Galaxy V-series UPSs se.com The next step in your sustainability journey eConversion mode: the unbeatable combination of power quality and efficiency Protect power to your load, reduce your electricity consumption, and meet your sustainability goals with up to 99% efficient, Class 1-compliant eConversion mode for Galaxy V-series UPSs. This patented high-efficiency mode achieves Class 1 categorization (the highest protection class), equaling Double Conversion, the legacy default operating mode of 3-phase UPSs. In eConversion mode, the inverter operates continuously, ensuring that if power fluctuates, your UPS can protect the load with no transfer time. eConversion mode also recharges batteries and provides power factor correction and harmonics compensation, making it a versatile solution for protecting both IT and non-IT loads. Operating at up to 99% efficiency isn't just good for the environment, it's good for your balance sheet. Within 10 years, the electricity savings of operating your UPS in eConversion typically equals up to 3x the price of the UPS. Delivering premium power protection and optimized total cost of ownership, eConversion is both the recommended operating mode for your Galaxy V-series UPS and an effortless step toward a more profitable business and a more sustainable world. 2 eConversion Third-party certified performance eConversion is the first UL-verified high efficiency mode. It has passed the rigorous testing of this 3rd-party, industry-leading certification agency. Class 1 protection Choose eConversion mode with confidence; its performance has been certified Class 1 per IEC ® 62040-3, the same class as Double Conversion. Excellent load protection, including patented zero-break transfer design The UPS continues to deliver input power factor correction, harmonic filtering, and no-break transfer to Double Conversion mode or battery operation. Maximum availability, third-party certified Enjoy the highest energy efficiency available today without sacrificing load protection. Every Galaxy V-series UPS includes eConversion mode and delivers these benefits: eConversion meets Class 1 of IEC 62040-3: zero-break transfer during power outage. 1000.11 10 Nominal Value (Voltage %) 100% 80% 60% 40% 20% 0% -20% -40% -60% -80% -100% 1,000 Overvoltage transient limit Undervoltage transient limit +10% -10% Transient duration in milliseconds (ms) eConversion Over 10 years of field deployment Since its launch in 2014, eConversion has been successfully deployed all over the world. Join thousands of customers who use it daily to protect their critical loads. Continuously charging batteries With eConversion mode, your batteries are ready when you need runtime. Ideal for IT and non-IT applications • Data centers • Factories • Commercial offices • Transportation • Hospitals Sustainably reduce your operating costs Using eConversion mode achieves 99% efficiency, which provides significant savings every year on your electricity bill. Compared to Double Conversion, the savings are typically equivalent to up to 3 times the UPS acquisition price after 10 years. Optimize your energy consumption eConversion mode conserves every year as much power as the electricity generated by 30 rooftop solar installations, equivalent to the electricity required to recharge 50 electric cars. Up to 3x reduction in electricity use 4 = = 1x 31x 53x Galaxy VL in eConversion Rooftop solar installations Cars powered $$$$ UPS Price + Electricity Electricity savings = up to 3x UPS price $$$ $$ $ 0 Year 1 Year 5 Year 10 eConversion 99% efficiency Double Conversion eConversion 97% efficiency Total Cost of Ownership, optimized UPS eConversion savings over 10 years UPS kW rating Electricity savings* Carbon emissions (metric tons) savings Equivalent solar rooftop production Cars powered Galaxy VS 150 kW $41,000 135 10 16 Galaxy VM 225 kW $73,000 243 17 28 Galaxy VL 500 kW $146,000 484 31 53 Galaxy VXL 1250 kW $394,000 1314 88 150 Galaxy VX 1500 kW $684,000 2300 154 263 *Model dependent; based on a market electricity price: $0.15 /kWh and CO2 emissions factor of 0.5 kg/kWh. The annual electricity and carbon emissions savings are done by comparing the UPS efficiency in Double Conversion mode to its efficiency in eConversion mode. Carbon emissions are calculated based on the world average reported by the International Energy Agency (IEA): https://www.iea.org/reports/global-energy-co2-status-report-2019/emissions Calculate your efficiency and carbon emissions savings using the eConversion vs Double Conversion calculator, using this link or the QR code on page 6: https://www.se.com/ww/en/work/solutions/system/s1/data-center-and-network-systems/ trade-off-tools/econversion-vs-double-conversion-calculator/ eConversion A unique combination eConversion, Double Conversion, or ECO mode? A comparative study For decades, Double Conversion has been used as the default mode in 3-phase UPSs. The main disadvantage is the very high amount of electricity used 24 hours a day, 365 days a year to permanently regulate the output with a very tight +/-1% voltage tolerance. The cost of electricity used to perform permanent regulation typically represents up to 3x the UPS price over 10 years, while permanently re-creating a perfect sinewave has no extra benefit to the load as even the most critical loads are insensitive to a +/-10% voltage. Legacy 3-phase 'Default' mode Legacy 'High-efficiency' mode Most important for the availability of critical loads is the no-break transfer, certified by Class 1 protection (the highest category). In eConversion, the load is powered by the grid as long as it is within tolerance, but the inverter is kept operating in parallel. This ensures a no-break transfer in case of an outage, surge, or short circuit, and ensures third-party certified, Class 1 output, which denotes the highest availability. In comparison, using ECO mode (the legacy high-efficiency mode) reduces load availability and is therefore not a preferred mode of operation for applications requiring maximum protection. Double Conversion eConversion ECO mode Voltage fluctuation ««« Frequency fluctuation ««« Recharge batteries ««« No transfer time ««« PF Correction ««« Protection class Class 1 Efficiency 96-97% Voltage fluctuation ««« Frequency fluctuation «« Recharge batteries ««« No transfer time ««« PF Correction ««« Protection class Class 1 Efficiency 99% Voltage fluctuation «« Frequency fluctuation «« Recharge batteries Option No transfer time No PF Correction No Protection class Class 3 Efficiency 99% Bypass switch Bypass switch Battery Battery Battery DC/DC DC/DC DC/DC AC in AC in AC in M2 M2 M2 M1 M1 M1 AC in AC in AC inLoad Load Load Inverter Inverter InverterPFC rectifier PFC rectifier PFC rectifier May be on to allow battery recharge Calculate your savings 6 Use our eConversion vs Double Conversion Calculator to quickly assess your potential energy savings, operating cost optimization, and CO2 emissions reduction by comparing the cost of running your Galaxy V-series UPS in eConversion mode vs Double Conversion mode. Scan this QR code with your phone camera, or access the calculator from the Schneider Electric Data Center Trade Off ToolsTM Web page: https://www.se.com/ww/en/work/solutions/system/s1/data-center-and-network- systems/trade-off-tools/econversion-vs-double-conversion-calculator/ If you have site-specific questions, our trained Field Service Representatives can perform a technical assessment of your site before you activate eConversion mode. To learn more, contact your Schneider Electric representative. On-screen savings meter If you already have a Galaxy V-series UPS, start using eConversion mode and watch the savings add up! eConversion Schneider Electric Industries SAS 35 rue Joseph Monier 92500 Rueil-Malmaison, France Tel : +33 (0)1 41 29 70 00 © 2024 Schneider Electric. All Rights Reserved. Schneider Electric | Life Is On is a trademark and the property of Schneider Electric SE, its subsidiaries, and affiliated companies • 998-22187559 To learn more about eConversion mode, contact your Schneider Electric representative or visit https://www.se.com/ww/en/work/solutions/eConversion- high-efficiency-UPS-mode About Schneider Electric: At Schneider Electric, we believe access to energy and digital is a basic human right. We empower all to make the most of their energy and resources, ensuring Life Is On everywhere, for everyone, at every moment. We provide energy and automation digital solutions

for efficiency and sustainability. We combine world-leading energy technologies, real-time automation, software and services into integrated solutions for Homes, Buildings, Data Centers, Infrastructure, and Industries. We are committed to unleash the infinite possibilities of an open, global, innovative community that is passionate about our Meaningful Purpose, Inclusive and Empowered values. www.se.com 3-Phase Uninterruptible Power Supply (UPS) Secure Power Portfolio www.se.com Public 2 Contents I. Overview 3 II. Our Portfolio 4 III. Products 3-Phase UPSs 5 Galaxy VS (10-150 kW) 6 Galaxy VM (160-225 kVA) 7 Galaxy VL (200-500 kW) 8 Galaxy VX (500-1500 kW) 9 Galaxy VXL (500-1250 kW) 10 Easy UPS 3S (10-40 kVA) 11 Easy UPS 3M (60-200 kVA) 12 Easy UPS 3M Advanced (100-250 kW) 13 Easy UPS 3L (250-600 kVA) 14 Galaxy 3L (250-600 kVA) 15 Easy UPS 3-Phase Modular (50-250 kW) 16 Galaxy PX (100-250 kW) 17 Symmetra PX (10-500 kVA) 18 Galaxy PW 2nd Gen (10-200 kVA) 19 3-Phase Lithium-ion Battery Cabinets 20 Galaxy Lithium-ion Battery Cabinets 21 3-Phase IT Power Distribution 22 Galaxy Power Distribution Units (PDUs) 23 Galaxy RPP 24 Configurable and Modular Power Distribution Units 25 Upsilon Static Transfer Switches 26 IV. Key Applications and Segments by Product 28 2 Schneider's purpose is to empower all to make the most of our energy and resources, bridging progress and sustainability for all. We call this Life Is On. Our mission is to be your digital partner for Sustainability and Efficiency. Schneider Electric is a world leader in power protection, solving today's energy challenges while setting the standard for quality and innovation with fully integrated solutions, enterprise-wide networks, data centers, mission-critical systems, and industrial/manufacturing processes. Overview Empowering all to make the most of our energy and resources, bridging progress and sustainability for all. 3 Public 4 Our Portfolio Fully integrated, end-to-end 3-phase UPS solutions help maintain your enterprise-wide networks, data centers, mission-critical systems, and industrial manufacturing processes. Our global portfolio of world-class products and services uniquely combines to offer end- to-end critical power solutions, providing customers with robust power protection, anytime/anywhere visibility, and peace of mind with EcoStruxure IT software and flexible service plans throughout the life cycle of their installations. Galaxy V Series UPSs Maximize your availability and sustainability and optimize your total cost of ownership. Our modular Galaxy V Series UPSs deliver superior performance in a compact footprint, with up to 99% efficiency in eConversion mode, scalability and internal redundancy options, and Galaxy Lithium-ion battery solutions, making them ideal for the data center or business-critical applications. Easy UPS 3-phase UPSs Quickly deploy power protection that optimizes your capital expenses. Easy UPS 3-phase range UPSs feature robust electrical specifications, ruggedizing features, and a compact, lightweight footprint that are ideal for commercial or industrial applications. Modular Data Centers Schneider Electric 3-phase UPSs are ideal for Modular Data Center applications. Contact your Schneider Electric representative to learn how you can increase your infrastructure capacity while shrinking your infrastructure footprint. 5 Products 3-phase UPSs Galaxy VS For external batteries: 10-75 kW (208V), 20-150 kW (400V/480V) With internal smart battery modules: 10-50 kW (208V), 10-100 kW (400V), 20-100 kW (480V) Sold: Worldwide 6 SE.com Features Applications & Segments • IT • Small and medium data centers • Business-critical applications • Edge • Commercial and industrial facilities • Marine • Healthcare, Oil & Gas, Transportation, Minerals, Metals, Mining, Power, Grid • High efficiency in eConversion mode (up to 99%) • Maximum availability with modular architecture • Innovative Live Swap of power modules • Parallel for capacity or redundancy—up to 4 UPSs • Internal redundancy with N+1 power modules • Flexible modular, classic, & Lithium-ion battery solutions • Compact design with optimized footprint • Touchscreen display with NMC • NMC with Secure Subscription License • EcoStruxure connected • Green Premium solution • Start-up service included Options • Battery flexibility, including Lithium-ion batteries • Single and parallel wallmount maintenance bypass panel • Classic and Modular Battery Cabinets • Battery Breaker Box and Battery Breaker Kit • IP52/NEMA 12 Kit • Seismic kits (OSHPD) • Network management card embedded with ethernet (NMP) and Modbus • Galaxy VS 20 kW (480V in, 400V out) up to 80 kW Internal Input Transformer for NAM Overview Galaxy VS is a highly efficient, modular, simple-to-deploy 3-phase UPS that delivers top performance to edge, small, and medium data centers, as well as critical infrastructure in commercial and industrial facilities. It offers increased availability, reduced operating costs, and first-class power protection for critical infrastructure. Galaxy VM For external batteries: 160-200 kVA (400V), 160-225 kVA (480V) Sold: Worldwide (except Japan) Features Applications & Segments • Mission-critical environments • Medium data centers • Industrial plants and applications • Facility infrastructure • Healthcare • Telecommunications • Highly efficient eConversion mode (up to 98.5%) • Integrated backfeed protection • Single-cabinet top and bottom cable entry • Full front-service access • Flexible modular, classic, and Lithium-ion battery solutions • Large color touch-screen display with built-in NMC • 65 kAIC rating standard • Compact footprint • Smart Power Test (SPoT) mode • OSHPD certified cabinets • Integrated casters for ease of mobility • EcoStruxure connected • Start-up service included Options • Classic and Modular Battery Cabinets • Management cards • Fuse kits • Wall-mounted battery breaker boxes • Parallel system bypass cabinets • Dust filter kits • System bypass cabinets • 208V transformers • Flywheel and Lithium-ion battery compatible • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License 7 Overview Galaxy VM is a highly efficient, modular 3-phase UPS that seamlessly integrates into medium data centers, industrial, or facilities applications. SE.com Public 8 Galaxy VL Applications & Segments • Mission-critical environments • Medium and large data centers • Colocation facilities • Computer rooms • Edge computing, Internet DC, Cloud computing • Light industry and commercial buildings • Infrastructure and transportation 8 For external batteries: 200-500 kW (400V/480V) Sold: Worldwide Overview Galaxy VL is a highly efficient, scalable 3-phase UPS featuring a modular, redundant design and low TCO for medium and large data centers and mission-critical environments. Minimize your total cost of ownership while expanding your business and maximizing your availability, reliability, and sustainability. With up to 99% efficiency in eConversion mode and fast power expansion with Live Swap, Galaxy VL is the most compact galaxy in the UPS universe. Make your data center or co-location facility more sustainable today. SE.com Features • Highly efficient eConversion mode (up to 99%) • Compact design, optimized footprint • Innovative Live Swap • Lithium-ion battery option • Parallel for capacity or redundancy—up to 6 UPSs • Scalable, modular design enables N+1 internal redundancy • Smart Power Test (SPoT) mode • Fault-tolerant design • Touchscreen display with NMC • Secure NMC Subscription License • Full front-service access • EcoStruxure connected • Green Premium solution • Startup service included Options • Classic battery cabinets • SKRU kit • Remote Centralized Display Box • Bottom Entry Cabinet 65kAIC Kit • Seismic (with option kit) • Replaceable dust filters • Backfeed protection options • Battery Breaker Box/Kit • NMC embedded with ethernet (NMP) and Modbus • Maintenance bypass cabinets Galaxy VX Features Applications & Segments • Mission-critical environments • Large/extra-large data centers • Industrial applications • Facility infrastructure • Cloud and Service providers • Colocation facilities • Finance, semiconductor, and manufacturing environments • Telecommunications, Healthcare • Highly efficient eConversion mode (up to 99%) • Cabinet-level scalability for capacity or redundancy • Dual mains input, top and bottom cable entry • Parallel for capacity or redundancy — up to 4 UPSs • Flywheel and Lithium-ion battery compatible • Internal redundancy with N+1 power cabinets • Smart Power Test (SPoT) mode • Touchscreen display with NMC • EcoStruxure connected • Startup service included Options • Battery pull box • Network Management Card (AP9640 / AP9641 / AP9643) with Secure NMC Subscription License • SmartSlot cards • Replaceable dust filters • Single feed kit 9 For external batteries: 500 scalable to 1500 kW N+1 (400V/480V) Sold: Worldwide Overview Galaxy VX is a highly efficient, modular 3-phase UPS scalable from 500 to 1500 kW in a single unit with high performance and flexible operating modes. Its scalability accommodates the changing needs of your rapidly expanding business, and its exceptional performance and abundance of cost-saving features reduce your energy costs and total cost of ownership. Galaxy VX is the ideal UPS for today's large data centers, cloud and colocation facilities, as well as mission-critical applications. SE.com • Parallel cable kit • Maintenance bypass cabinets • Classical battery cabinets Public 10 Galaxy VXL 10 For external batteries: 500-1250 kW (400V) Sold: All IEC countries worldwide SE.com Features Applications & Segments • Large and extra-large data centers • Colocation facilities • Computer rooms • Light industry & commercial buildings • Cloud & Service Provider facilities • Semiconductor industry • Manufacturing critical line • Energy and Chemicals • Bank, Finance, Insurance • Pre-fabricated systems • High efficiency eConversion mode (up to 99%) • Compact design, optimized footprint only 1.2m2 • Innovative Live Swap • Lithium-ion battery integration • EcoStruxure connected • Scalable, modular design enables N+1 internal redundancy • Reliable and fault-tolerant design • Sustainable solution • Full front access • Unity power factor @40°C, kVA=kW • Touchscreen display with NMC • High short circuit level 100kA • Secure NMC Subscription License • Smart Power Test (SPoT) mode • Startup service included Options • Battery Breaker Box/Kit • Empty Battery Cabinet Overview Galaxy VXL is a highly efficient, compact, and modular 3-phase UPS with Live Swap. With its industry-leading compact design, high-density technology, and fault-tolerant architecture, Galaxy VXL maximizes availability, operational efficiency, and critical load protection while minimizing TCO. This UPS delivers up to 97.5% efficiency in double conversion mode and up to 99% in eConversion mode, reducing the UPS Carbon emissions by a factor of two. Galaxy VXL offers proactive asset management services to give you peace of mind anytime, anywhere. Start-up service is included. • Galaxy Lithium-ion Battery Cabinets • Air filter kit • Parallel Communications Kit • Seismic kit, and other options Public 11 Easy UPS 3S For external batteries: 10-40 kVA (400V) With and/or for internal batteries: 10-40 kVA (208V/400V) Sold: US, Canada, Mexico, and all IEC countries worldwide, except Japan Features Applications & Segments • Small data centers • Commercial buildings & light industrial applications • Business-critical applications • Healthcare, Telecommunication, Transportation, Manufacturing facilities • Non-IT • Easy to install and start up; minimal footprint • Delivers up to 96% efficiency • Wide operating temperature range and strong overload protection • Replaceable dust filters • Strong protection against harsh environments with robust electrical specifications • Conformal coating • Easy Loop Test to verify UPS performance before you connect your load • Parallel for capacity or redundancy—up to 4 UPSs • Easy to manage with mimic panel • EcoStruxure connected • Long life battery string ready Options • Cold Start kit • Parallel maintenance bypass, up to 2 units for 400V or 3 units for 208V • Battery Breaker Box and Battery Breaker Kit • Empty battery cabinets • Standard 7Ah or 9Ah battery modules • NMC with Secure Subscription License • Start-up service 11 Overview Easy UPS 3S (400V) is an easy to install, use, and service 3-Phase UPS available for external batteries or with and/or for internal batteries designed for small data centers and other business critical applications. Easy UPS 3S (208V) is an easy to install, use, and service 3-Phase UPS for internal batteries designed for small data centers, commercial buildings, non-IT, and light industrial applications. SE.com: 400V / 208V Public 12 Easy UPS 3M For external batteries: 60-200 kVA (400V) and 50-100 kVA (208V) With internal batteries: 60-80 kVA (400V) Sold: 208V countries of South America and Caribbean Islands, and all IEC countries worldwide, except Japan 12 SE.com Features Applications & Segments • Small and medium data centers and computer rooms • Electrical rooms • Business-critical applications • Commercial buildings • Healthcare, Telecommunication, Transportation, Manufacturing facilities • Start-up included • Easy deployment and compact footprint • Delivers up to 95.5% efficiency • Wide operating temperature range and strong overload protection • Strong protection against harsh environments with robust electrical specifications • Easy Loop Test to verify UPS performance before you connect your load • IP20 protection (extra protection with IP30, IP40, and/or IPX2 Option Kits) • Replaceable dust filters • Parallel for capacity or redundancy— up to 6 UPSs • Front and rear access service • Easy to manage with touchscreen display • Embedded NMC with Subscription License • EcoStruxure connected Options • Parallel and unitary maintenance bypass panel • Modular Battery cabinet • Classic Battery Cabinets with batteries • Empty battery cabinets • Battery Breaker Box and Battery Breaker Kit • Battery string or high-capacity battery string • Lithium-ion battery option Overview Easy UPS 3M 60-200 kVA (400V) and 50-100 kVA (208V) for external batteries, and 60-80 kVA (400V) with internal batteries is an easy to install, connect, use, and service 3-Phase UPS for small and medium data centers, electrical rooms, and other business-critical applications. Public 13 Easy UPS 3M Advanced For external batteries: 100-250 kW (400V) Sold: India Features Applications & Segments • Small and medium data centers • Commercial buildings • Light industrial applications • Government & Public Sector Units • Healthcare, Telecommunication, Transportation, Retail, Process Automation • Start-up included to optimizes your system's performance, quality, and safety • Scalable 100 kW to 250 kW for pay as you grow • Modular design, enabling easy serviceability • Easy deployment and compact footprint • Delivers up to 96% efficiency • Single frame capable up to 250 kW in capacity with Internal N+1 redundancy for up to 200 kW N+1 • Wide operating temperature range and strong overload protection • Pluggable Draw In/Out type power module • kVA = kW up to 40°C • Replaceable dust filters • Front and rear access service • Easy to manage with 7" touchscreen display • EcoStruxure connected • Made in India enables direct sales to Government, Public Sector Units, and Infrastructure Projects Options • Power module • Maintenance Bypass Panel • Battery Breaker Box and Battery Breaker Kit 13 Overview Easy UPS 3M Advanced—part of the Easy UPS 3-phase range—is an easy-to-install, connect, use, service, and scale 100-250 kW (400V) 3-Phase UPS made in India that is ideal for small and medium businesses, data centers, and other mission-critical applications in India. SE.com • Battery Temperature Sensors • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License Public 14 Easy UPS 3L For external batteries: 250-600 kW (400V) Sold: All IEC countries worldwide, except Japan and China Applications & Segments • Medium and large commercial buildings • Light industrial applications • Computer room and regional data centers • Healthcare, Telecommunication, Transportation, Financial, Government • Non-IT 14 Overview Easy UPS 3L 250-600 kVA (400V) is an easy to configure, use, and service 3-Phase UPS that delivers high availability and predictability to medium and large commercial buildings and light industrial applications. SE.com Features • Easy deployment and compact footprint • Delivers up to 96% efficiency • Power Module for fault-tolerant design • Streamlined installation and service • Protection against harsh environments with robust electrical specifications and ruggedizing features, including conformal coating • Replaceable dust filter • 1+1 redundant UPSs can share a common battery bank, reducing battery costs • IP20 (extra protection with IP31 option kit) • Smart Test mode optimizes site acceptance testing costs without requiring a load bank • Parallel up to 5 UPSs for capacity or 5+1 UPSs for redundancy • Supports 4+4 redundant configurations • Top cable entry • EcoStruxure connected • Embedded NMC with Secure NMC Subscription License • Start-up service included Options • Maintenance Bypass Panel • Classic Battery Cabinets • Empty battery cabinets • Battery Breaker Box and Battery Breaker Kit • Cold Start kit • Lithium-ion battery option Public 15 Galaxy 3L For external batteries: 250-600 kW (400V) Sold: China Features Applications & Segments • Medium and large data centers, and colocation facilities • Commercial and light industrial applications • Edge applications and computer rooms • Telecommunication, Healthcare, Government Transportation, Manufacturing, Finance • Easy deployment and compact footprint • Delivers up to 96% efficiency • Fault-tolerant design • Protection against harsh environments with robust electrical specifications and ruggedizing features • 1+1 redundant UPSs can share a common battery bank, reducing battery costs • Top cable entry • Replaceable dust filter • Embedded Network Management Card • IP20 (extra protection with IP31 option kit) • Smart Test mode optimizes site acceptance testing costs without requiring a load bank • Parallel up to 5 UPSs for capacity or 5+1 UPSs for redundancy • Supports 4+4 redundant configurations • 7-inch display • EcoStruxure connected • Start-up included Options • Maintenance Bypass Panel • Battery Breaker Box and Battery Breaker Kit • Classic Battery Cabinets • Empty battery cabinets • Cold Start kit 15 Overview Galaxy 3L 250-600 kVA (400V) is an easy to configure, use, and service 3-Phase UPS that delivers high availability and predictability to medium and large data centers, commercial buildings, and light industrial applications in China. SE.com • Bottom entry Cabinet • Lithium-ion battery option Public 16 Easy UPS 3-Phase Modular For external batteries: 50-250 kW (400V) Sold: All IEC countries worldwide, except Japan and China 16 Overview Easy UPS 3-Phase Modular 50-250 kW (400V) delivers robust power protection and availability in a capital-expenditure-friendly package. It is easy to select, quote, install, and maintain, with modular, redundant, scalable options and Live Swap modules in a compact footprint. SE.com Features Applications & Segments • Easy to select, configure, start up, use, and service • Up to 96% efficiency in double conversion mode • Third-party verified Live Swap functionality for fast MTTR and expansion with no scheduled downtime • Add Live Swap power modules as demand grows • Modular design with 50 kW power module enables N+1 redundancy to increase availability • Scalable design: pay as you grow • Up to 250 kW N+1 in a black one-rack design to conserve valuable real estate • Unity power factor @40°C • EcoStruxure connected for peace of mind anytime, anywhere • Parallel 4+0, increasing power capacity to 1 MW • Neutral Lithium-ion Function • Start-up service included • Bottom Entry Cabinet • Empty Battery Cabinet • Battery Breaker Box and Battery Breaker Kit • Maintenance Bypass Panel • Parallel Communications Kit • Redundant Intelligence Module • Lithium-ion battery option • Classic Battery Cabinet • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License • Other options: Depth Adapter, Backfeed Kit, Wide Seismic Kit, Battery Temperature Sensor • Small and medium data centers • Telecommunication • Transportation • Healthcare • Process Automation Options • Commercial buildings • Retail Public 17 Galaxy PX UPS 100-250 kW (400V) Sold: China Features Applications & Segments • Simple to select, configure, start up, use, and service • Up to 96% efficiency in double conversion mode • Third-party verified Live Swap functionality for fast MTTR and expansion with no scheduled downtime • Compact footprint with 10-inch touchscreen display • Modular design with 50 kW power module enables N+1 redundancy to increase availability • Parallel 4+0, increasing power capacity to 1 MW • Up to 250 kW N+1 in a black one-rack design to conserve valuable real estate • Scalable design: optimize capex, pay as you grow • Unity power factor @40°C • EcoStruxure connected for peace of mind anytime, anywhere • Neutral Lithium-ion Function • Start-up service included Options • Bottom Entry Cabinet • Depth Adapter • Neutral Disconnection Kit for 250 KW • Battery Temperature Sensor • Parallel Communications Kit • Lithium-ion battery option • 600mm wide Seismic Kit for 250 kW • Backfeed Kit 250 kW • Network Management Card • Redundant Intelligence Module 17 Overview Galaxy PX 100-250 kW (400V) UPS delivers robust power protection and availability in a capital-expenditure- friendly package. It is simple to select, quote, install, and maintain, with modular, redundant, scalable options, and Live Swap modules in a compact footprint. SE.com • Small & medium data centers • Telecommunication • Transportation • Healthcare • Process Automation• Commercial buildings • Retail Symmetra PX 400V: 16-500 kW with Symmetra PX 48 All-in-One, 96/160, & 250/500 208V: 10-100 kW with Symmetra PX 20, 40, & 100 480V: 100-500 kW with Symmetra PX 100 & 250/500 Sold: Worldwide 250/500 20 40 48 AIO 96/160 100 250/500 18 SE.com Features Applications & Segments • Data closet • Small, medium, and large data centers • Line up and match NetShelter form factor • Configurable for N+1 internal redundancy • Redundant intelligent modules • Scalable power capacity • Modular power, battery, bypass, and intelligent control modules • Parallel up to 4 UPSs (Symmetra PX 250/500 only) • Dual mains input, top or bottom feed • Embedded power distribution (PX20, 48) • EcoStruxure connected • Network Management Card with Secure NMC Subscription Licenses • Start-up service included Options • Secondary network management card (HTTP/Telnet/SNMP) • Seismic kits (OSHPD) • Battery breaker enclosure Overview Symmetra PX is a high performance, right-sized, modular, scalable, 3-phase UPS that offers power protection with high availability and efficiency for small, medium, and large data centers and mission-critical environments. Made up of dedicated and redundant modules, this architecture can scale power and runtime as demand grows or as higher levels of availability are required. • Extended runtime battery frames • Classic battery cabinets: PX100, 96/160, 250/500 • Lithium-ion battery option for Symmetra PX 250/500 • High-density zones of large data centers • Mission-critical environments • Maintenance bypass cabinets with distribution: PX40, 100, 96/160, 250/500 • Configurable power distribution: PX20, 40, 100 • Modular power distribution: PX48, 96/160, 100 Public 19 Galaxy PW 2nd Gen Features Applications & Segments • Petroleum Petrochemical Gas • Metallurgy • Power Plant • Medical • Semiconductor • Transportation • Food & Beverage • Mining • Manufacturing • Supports dual input • Overload capacity: 125% 10 min; 150% 1 min • Parallel up to 3+1 (4+0) • ISTA 2B • Robust design for harsh environments • Phase rotation check • Standard protection class: IP31 • Operating temperature: 0-40°C • Supports DC cold start • Designed for easy service • Start-up service included Options • AP9547 Network Management Card with Secure NMC Subscription License • Replaceable dust filters • Parallel Communications Kit • Backfeed Kits 19 10-200 kVA (400V) transformer-based UPS Sold: Europe, Middle East & Africa, Pacific, and Greater China Overview Galaxy PW 2nd Gen is a 10-200 kVA (400V) transformer-based UPS for industrial applications. The DC busbar voltage covers 220VDC and 384VDC, and uses a reliable 6-pulse or 12-pulse SCR rectifier. SE.com • Cable Adapter Kits for Galaxy Pwi • IP42 Kit (ETO) Products 3-phase UPSs Products 3-phase Lithium-ion Battery Cabinets 20 Public 21 Galaxy Lithium-ion Battery Cabinets Features Applications & Segments • Data centers, colocation, computer rooms • Edge computing, Internet DC, cloud computing • Computer rooms • Light industrial and commercial buildings • Infrastructure and transportation • Telecommunications and networking • Critical power infrastructures • Emergency lighting • UP9540A fire tested compliance • 67Ah LMO/NCM battery system • Double your battery life vs. VRLA solutions • Up to 70% more compact footprint frees up floor space for revenue-generating equipment • Boost availability with 2-3x faster recharge rates than VRLA solutions • Built-in 3-level battery management system (BMS) • Green Premium solution • Aesthetic match with Galaxy V Series UPSs • Self feeding SMPS simplifies installation • Fast, simple installation — cabinet ships pre- assembled, except battery modules, and rolls quickly into place • Enhance employee protection with modular touch- safe design, breaker covers, and built-in fuse protection at the battery cell and cabinet level • Seismic kit • EcoStruxure connected • Start-up service options available 21 For Galaxy VS, VM, VL, VX, VXL; Symmetra PX 250/500; Symmetra MW; Easy UPS 3M; Easy UPS 3L/Galaxy 3L; Easy UPS 3-Phase Modular; and Galaxy PX Sold: Worldwide Overview A Galaxy Lithium-ion Battery Cabinet are compact, lightweight, long-lasting, and sophisticated energy storage solution for Galaxy V series and Easy 3-phase UPSs in data centers, industrial processes, and critical infrastructures. This UL9540A-compliant battery solution reduces battery footprint and weight by up to 70%, allowing more effective use of space. Lithium-ion batteries reduce total cost of ownership, both by doubling battery life and by operating at higher temperatures, reducing cooling requirements. SE.com 22 Products 3-phase IT Power Distribution Public 23 Power Distribution Units (PDUs) Features Applications • Small, medium, and large data centers • Colocation facilities • Compartmental design simplifies asset access allocation • Meets the demanding scalability needs of any data center of any size • Factory installed and tested Square D breaker panel configured to meet the unique needs of your site • Easy to install and service with top and bottom cable entry • Low total cost of ownership • Seismic cabinet (OSHPD) • 7-inch display interface • EcoStruxure connected 23 Overview Power Distribution Units are reliable, scalable, and intelligent high-density power distribution solutions ideal for installation in the electrical rooms of data centers. SE.com 400 & 500 kVA (480V) Sold: US, Central America Options • Copper or aluminum transformers • Main input switch or breaker • Main output breaker • Advanced metering • Wide range of 250 Amp, 400 Amp, and 600 Amp branch breaker options from Schneider Electric's PowerPact J- and L-frame breaker series • EPO • Cloud service providers • Industrial applications 400 & 500 kVA (Aluminum) and 400 kVA (Copper) 500 kVA (Copper) Public 24 Galaxy RPP Features Applications • Data centers • Colocation facilities • Cloud service providers • Compact footprint and easy front-access design • Supports installation against walls, back-to-back, or in your EcoStruxure Pod Data Center • Flexible configuration, with factory installed and tested Square D breaker panels configured to your site requirements • Meets the demanding scalability needs of any large data center • PowerLogic Branch Circuit Power Meter monitors single or dual feed installations • Compartmental design simplifies asset access allocation • Top and bottom cable entry • Compatible with all Schneider Electric Power Distribution Units • 7-inch touchscreen display • EcoStruxure connected 24 Overview Galaxy RPP (Remote Power Panels) 250 and 400 Amp (120V/208V) offers highly configurable, highly modular, high-density row-level power distribution for data centers and colocation facilities. SE.com 250 & 400 Amp (120V/208V) Sold: US, Canada, Central America Options • L-frame or J-frame main input breakers • NP, NQ, or IP2X panelboard • QO, QOB, or EDB distribution breakers • Surge protection devices • Start-up service options available Configurable and Modular Power Distribution Units • Top or bottom cable entry (60/150 kW PDU) • Flexible configure-to-order options • Factory assembled and tested • Scalable • Modbus supported • Integrated monitoring • Network enabled • No side access required • Preconfigured cord sets • Compatible with StruxureWare Data Center Expert • Branch circuit monitoring • Power distribution modules with locking connectors (Modular) 25 Features Applications • Small, medium, or large data centers Overview Modular Power Distribution Units (PDUs) mitigate the need to predict the future requirements and configurations of your data center. Configurable Power Distribution Units bring agility, availability, and speed of deployment to your data center. Our factory-tested power distribution units are built to your exact specifications, support overhead or underfloor distribution, and feature a convenient, portable rack form factor. Options 120/208/230/400/480/600V: 72-277 kW (Modular) 208V/480V/600V: 40-150 kW (Configurable) Sold: Worldwide; product availability varies by region Modular Configurable • Shielding troughs Startup service SE.com: Configurable and Modular Upsilon Static Transfer Switches 30-630A standard; 800-1250A on request Sold: All IEC regions worldwide • Industrial applications • Data centers • Telecommunication centers • Infrastructure • Simplifies installation and maintenance while minimizing space requirements • Independent control boards, dual cooling systems, and power supplies ensure high reliability performance • Small footprint reduces required floor space • Text and mimic diagrams display modes of operation, system parameters, and alarms • Allows isolation of a source for maintenance without interrupting power to the protected loads Options • Communication: JBus/Modbus card (supplied as standard), status information card (supplied as standard) • Open frame version Overview Upsilon Static Transfer Switches (STS) provides true redundance and exceptional high reliability for automatic power supply transfer to a range of equipment from two independent and redundant power sources. Static Transfer Switches automatically transfer power to a stable alternate source in less than 4ms under normal operating conditions. Even under extreme conditions, such as 180 degrees out of phase, the STS will have detection and automatic transfer times that are up to 10 times faster than many other switches. 26 SE.com • PDU (36 16A circuit breakers incorporated in the H = 1900 cell, up to 100 A) • Connection at the top of the unit Features Applications & Segments 27 Key Applications and Segments by Product 28 IT Small data centers Medium data centers Large data centers Colocation facilities Cloud computing Commercial facilities Industrial facilities Healthcare Transportation Telecommunications Energy & Chemical Metal, Minerals, and Mining Consumer Packaged Goods Semi Conductor Galaxy VS Galaxy VM Galaxy VL Galaxy VX Galaxy VXL Easy UPS 3S Easy UPS 3M Easy UPS 3M Advanced Easy UPS 3L Galaxy 3L Easy UPS 3-Phase Modular Galaxy PX Symmetra PX Galaxy PW 2nd Gen Galaxy Lithium-ion Battery Cabinets Power Distribution Units (PDUs) Galaxy RPP Configurable and Modular PDUs Upsilon Static Transfer Switches ü Key Applications and Segments by Product To learn more about Schneider Electric 3-Phase UPS products and solutions, contact your Schneider Electric representative or visit www.se.com. Schneider Electric 35 rue Joseph Monier 92500 Rueil Malmaison France ©2024 Schneider Electric. All Rights Reserved. Schneider Electric | Life Is On, Galaxy, and EcoStruxure are trademarks and the property of Schneider Electric SE, its subsidiaries, and affiliated companies. All other trademarks are the property of their respective owners. Product specifications are subject to change without notice and are provided "as is" without warranty of any kind, express or implied. See apc.com for the most up to date product specifications. • 998-19858418_GMA-US 28 3-Phase Uninterruptible Power Supply (UPS) Secure Power Portfolio www.se.com Public 2 Contents I. Overview 3 II. Our Portfolio 4 III. Products 3-Phase UPSs 5 Galaxy VS (10-150 kW) 6 Galaxy VM (160-225 kVA) 7 Galaxy VL (200-500 kW) 8 Galaxy VX (500-1500 kW) 9 Galaxy VXL (500-1250 kW) 10 Easy UPS 3S (10-40 kVA) 11 Easy UPS 3M (60-200 kVA) 12 Easy UPS 3M Advanced (100-250 kW) 13 Easy UPS 3L (250-600 kVA) 14 Galaxy 3L (250-600 kVA) 15 Easy UPS 3-Phase Modular (50-250 kW) 16 Galaxy PX (100-250 kW) 17 Symmetra PX (10-500 kVA) 18 Galaxy PW 2nd Gen (10-200 kVA) 19 3-Phase Lithium-ion Battery Cabinets 20 Galaxy Lithium-ion Battery Cabinets 21 3-Phase IT Power Distribution 22 Galaxy Power Distribution Units (PDUs) 23 Galaxy RPP 24 Configurable and Modular Power Distribution Units 25 Upsilon Static Transfer Switches 26 IV. Key Applications and Segments by Product 28 2 Schneider's purpose is to empower all to make the most of our energy and resources, bridging progress and sustainability for all. We call this Life Is On. Our mission is to be your digital partner for Sustainability and Efficiency. Schneider Electric is a world leader in power protection, solving today's energy challenges while setting the standard for quality and innovation with fully integrated solutions, enterprise-wide networks, data centers, mission-critical systems, and industrial/manufacturing processes. Overview Empowering all to make the most of our energy and resources, bridging progress and sustainability for all. 3 Public 4 Our Portfolio Fully integrated, end-to-end 3-phase UPS solutions help maintain your enterprise-wide networks, data centers, mission-critical systems, and industrial manufacturing processes. Our global portfolio of world-class products and services uniquely combines to offer end- to-end critical power solutions, providing customers with robust power protection, anytime/anywhere visibility, and peace of mind with EcoStruxure IT software and flexible service plans throughout the life cycle of their installations. Galaxy V Series UPSs Maximize your availability and sustainability and optimize your total cost of ownership. Our modular Galaxy V Series UPSs deliver superior performance in a compact footprint, with up to 99% efficiency in eConversion mode, scalability and internal redundancy options, and Galaxy Lithium-ion battery solutions, making them ideal for the data center or business-critical applications. Easy UPS 3-phase UPSs Quickly deploy power protection that optimizes your capital expenses. Easy UPS 3-phase range UPSs feature robust electrical specifications, ruggedizing features, and a compact, lightweight footprint that are ideal for commercial or industrial applications. Modular Data Centers Schneider Electric 3-phase UPSs are ideal for Modular Data Center applications. Contact your Schneider Electric representative to learn how you can increase your infrastructure capacity while shrinking your infrastructure footprint. 5 Products 3-phase UPSs Galaxy VS For external batteries: 10-75 kW (208V), 20-150 kW (400V/480V) With internal smart battery modules: 10-50 kW (208V), 10-100 kW (400V), 20-100 kW (480V) Sold: Worldwide 6 SE.com Features Applications & Segments • IT • Small and medium data centers • Business-critical applications • Edge • Commercial and industrial facilities • Marine • Healthcare, Oil & Gas, Transportation, Minerals, Metals, Mining, Power, Grid • High efficiency in eConversion mode (up to 99%) • Maximum availability with modular architecture • Innovative Live Swap of power modules • Parallel for capacity or redundancy—up to 4 UPSs • Internal redundancy with N+1 power modules • Flexible modular, classic, & Lithium-ion battery solutions • Compact design with optimized footprint • Touchscreen display with NMC • NMC with Secure Subscription License • EcoStruxure connected • Green Premium solution • Start-up service included Options • Battery flexibility, including Lithium-ion batteries • Single and parallel wallmount maintenance bypass panel • Classic and Modular Battery Cabinets • Battery Breaker Box and Battery Breaker Kit • IP52/NEMA 12 Kit • Seismic kits (OSHPD) • Network management card embedded with ethernet (NMP) and Modbus • Galaxy VS 20 kW (480V in, 400V out) up to 80 kW Internal Input Transformer for NAM Overview Galaxy VS is a highly efficient, modular, simple-to-deploy 3-phase UPS that delivers top performance to edge, small, and medium data centers, as well as critical infrastructure in commercial and industrial facilities. It offers increased availability, reduced operating costs, and first-class power protection for critical infrastructure. Galaxy VM For external batteries: 160-200 kVA (400V), 160-225 kVA (480V) Sold: Worldwide (except Japan) Features Applications & Segments • Mission-critical environments • Medium data centers • Industrial plants and applications • Facility infrastructure • Healthcare • Telecommunications • Highly efficient eConversion mode (up to 98.5%) • Integrated backfeed protection • Single-cabinet top and bottom cable entry • Full front-service access • Flexible modular, classic, and Lithium-ion battery solutions • Large color touch-screen display with built-in NMC • 65 kAIC rating standard • Compact footprint • Smart Power Test (SPoT) mode • OSHPD certified cabinets • Integrated casters for ease of mobility • EcoStruxure connected • Start-up service included Options • Classic and Modular Battery Cabinets • Management cards • Fuse kits • Wall-mounted battery breaker boxes • Parallel system bypass cabinets • Dust filter kits • System bypass cabinets • 208V transformers • Flywheel and Lithium-ion battery compatible • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License 7 Overview Galaxy VM is a highly efficient, modular 3-phase UPS that seamlessly integrates into medium data centers, industrial, or facilities applications. SE.com Public 8 Galaxy VL Applications & Segments • Mission-critical environments • Medium and large data centers • Colocation facilities • Computer rooms • Edge computing, Internet DC, Cloud computing • Light industry and commercial buildings • Infrastructure and transportation 8 For external batteries: 200-500 kW (400V/480V) Sold: Worldwide Overview Galaxy VL is a highly efficient, scalable 3-phase UPS featuring a modular, redundant design and low TCO for medium and large data centers and mission-critical environments. Minimize your total cost of ownership while expanding your business and maximizing your availability, reliability, and sustainability. With up to 99% efficiency in eConversion mode and fast power expansion with Live Swap, Galaxy VL is the most compact galaxy in the UPS universe. Make your data center or co-location facility more sustainable today. SE.com Features • Highly efficient eConversion mode (up to 99%) • Compact design, optimized footprint • Innovative Live Swap • Lithium-ion battery option • Parallel for capacity or redundancy—up to 6 UPSs • Scalable, modular design enables N+1 internal redundancy • Smart Power Test (SPoT) mode • Fault-tolerant design • Touchscreen display with NMC • Secure NMC Subscription License • Full front-service access • EcoStruxure connected • Green Premium solution • Startup service included Options • Classic battery cabinets • SKRU kit • Remote Centralized Display Box • Bottom Entry Cabinet 65kAIC Kit • Seismic (with option kit) • Replaceable dust filters • Backfeed protection options • Battery Breaker Box/Kit • NMC embedded with ethernet (NMP) and Modbus • Maintenance bypass cabinets Galaxy VX Features Applications & Segments • Mission-critical environments • Large/extra-large data centers • Industrial applications • Facility infrastructure • Cloud and Service providers • Colocation facilities • Finance, semiconductor, and manufacturing environments • Telecommunications, Healthcare • Highly efficient eConversion mode (up to 99%) • Cabinet-level scalability for capacity or redundancy • Dual mains input, top and bottom cable entry • Parallel for capacity or redundancy — up to 4 UPSs • Flywheel and Lithium-ion battery compatible • Internal redundancy with N+1 power cabinets • Smart Power Test (SPoT) mode • Touchscreen display with NMC • EcoStruxure connected • Startup service included Options • Battery pull box • Network Management Card (AP9640 / AP9641 / AP9643) with Secure NMC Subscription License • SmartSlot cards • Replaceable dust filters • Single feed kit 9 For external batteries: 500 scalable to 1500 kW N+1 (400V/480V) Sold: Worldwide Overview Galaxy VX is a highly efficient, modular 3-phase UPS scalable from 500 to 1500 kW in a single unit with high performance and flexible operating modes. Its scalability accommodates the changing needs of your rapidly expanding business, and its exceptional performance and abundance of cost-saving features reduce your energy costs and total cost of ownership. Galaxy VX is the ideal UPS for today's large data centers, cloud and colocation facilities, as well as mission-critical applications. SE.com • Parallel cable kit • Maintenance bypass cabinets • Classical battery cabinets Public 10 Galaxy VXL 10 For external batteries: 500-1250 kW (400V) Sold: All IEC countries worldwide SE.com Features Applications & Segments • Large and extra-large data centers • Colocation facilities • Computer rooms • Light industry & commercial buildings • Cloud & Service Provider facilities • Semiconductor industry • Manufacturing critical line • Energy and Chemicals • Bank, Finance, Insurance • Pre-fabricated systems • High efficiency eConversion mode (up to 99%) • Compact design, optimized footprint only 1.2m2 • Innovative Live Swap • Lithium-ion battery integration • EcoStruxure connected • Scalable, modular design enables N+1 internal redundancy • Reliable and fault-tolerant design • Sustainable solution • Full front access • Unity power factor @40°C, kVA=kW • Touchscreen display with NMC • High short circuit level 100kA • Secure NMC Subscription License • Smart Power Test (SPoT) mode • Startup service included Options • Battery Breaker Box/Kit • Empty Battery Cabinet Overview Galaxy VXL is a highly efficient, compact, and modular 3-phase UPS with Live Swap. With its industry-leading compact design, high-density technology, and fault-tolerant architecture, Galaxy VXL maximizes availability, operational efficiency, and critical load protection while minimizing TCO. This UPS delivers up to 97.5% efficiency in double conversion mode and up to 99% in eConversion mode, reducing the UPS Carbon emissions by a factor of two. Galaxy VXL offers proactive asset management services to give you peace of mind anytime, anywhere. Start-up service is included. • Galaxy Lithium-ion Battery Cabinets • Air filter kit • Parallel Communications Kit • Seismic kit, and other options Public 11 Easy UPS 3S For external batteries: 10-40 kVA (400V) With and/or for internal batteries: 10-40 kVA (208V/400V) Sold: US, Canada, Mexico, and all IEC countries worldwide, except Japan Features Applications & Segments • Small data centers • Commercial buildings & light industrial applications • Business-critical applications • Healthcare, Telecommunication, Transportation, Manufacturing facilities • Non-IT • Easy to install and start up; minimal footprint • Delivers up to 96% efficiency • Wide operating temperature range and strong overload protection • Replaceable dust filters • Strong protection against harsh environments with robust electrical specifications • Conformal coating • Easy Loop Test to verify UPS performance before you connect your load • Parallel for capacity or redundancy—up to 4 UPSs • Easy to manage with mimic panel • EcoStruxure connected • Long life battery string ready Options • Cold Start kit • Parallel maintenance bypass, up to 2 units for 400V or 3 units for 208V • Battery Breaker Box and Battery Breaker Kit • Empty battery cabinets • Standard 7Ah or 9Ah battery modules • NMC with Secure Subscription License • Start-up service 11 Overview Easy UPS 3S (400V) is an easy to install, use, and service 3-Phase UPS available for external batteries or with and/or for internal batteries designed for small data centers and other business critical applications. Easy UPS 3S (208V) is an easy to install, use, and service 3-Phase UPS for internal batteries designed for small data centers, commercial buildings, non-IT, and light industrial applications. SE.com: 400V / 208V Public 12 Easy UPS 3M For external batteries: 60-200 kVA (400V) and 50-100 kVA (208V) With internal batteries: 60-80 kVA (400V) Sold: 208V countries of South America and Caribbean Islands, and all IEC countries worldwide, except Japan 12 SE.com Features Applications & Segments • Small and medium data centers and computer rooms • Electrical rooms • Business-critical applications • Commercial buildings • Healthcare, Telecommunication, Transportation, Manufacturing facilities • Start-up included • Easy deployment and compact footprint • Delivers up to 95.5% efficiency • Wide operating temperature range and strong overload protection • Strong protection against harsh environments with robust electrical specifications • Easy Loop Test to verify UPS performance before you connect your load • IP20 protection (extra protection with IP30, IP40, and/or IPX2 Option Kits) • Replaceable dust filters • Parallel for capacity or redundancy— up to 6 UPSs • Front and rear access service • Easy to manage with touchscreen display • Embedded NMC with Subscription License • EcoStruxure connected Options • Parallel and unitary maintenance bypass panel • Modular Battery cabinet • Classic Battery Cabinets with batteries • Empty battery cabinets • Battery Breaker Box and Battery Breaker Kit • Battery string or high-capacity battery string • Lithium-ion battery option Overview Easy UPS 3M 60-200 kVA (400V) and 50-100 kVA (208V) for external batteries, and 60-80 kVA (400V) with internal batteries is an easy to install, connect, use, and service 3-Phase UPS for small and medium data centers, electrical rooms, and other business-critical applications. Public 13 Easy UPS 3M Advanced For external batteries: 100-250 kW (400V) Sold: India Features Applications & Segments • Small and medium data centers • Commercial buildings • Light industrial applications • Government & Public Sector Units • Healthcare, Telecommunication, Transportation, Retail, Process Automation • Start-up included to optimizes your system's performance, quality, and safety • Scalable 100 kW to 250 kW for pay as you grow • Modular design, enabling easy serviceability • Easy deployment and compact footprint • Delivers up to 96% efficiency • Single frame capable up to 250 kW in capacity with Internal N+1 redundancy for up to 200 kW N+1 • Wide operating temperature range and strong overload protection • Pluggable Draw In/Out type power module • kVA = kW up to 40°C • Replaceable dust filters • Front and rear access service • Easy to manage with 7" touchscreen display • EcoStruxure connected • Made in India enables direct sales to Government, Public Sector Units, and Infrastructure Projects Options • Power module • Maintenance Bypass Panel • Battery Breaker Box and Battery Breaker Kit 13 Overview Easy UPS 3M Advanced—part of the Easy UPS 3-phase range—is an easy-to-install, connect, use, service, and scale 100-250 kW (400V) 3-Phase UPS made in India that is ideal for small and medium businesses, data centers, and other mission-critical applications in India. SE.com • Battery Temperature Sensors • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License Public 14 Easy UPS 3L For external batteries: 250-600 kW (400V) Sold: All IEC countries worldwide, except Japan and China Applications & Segments • Medium and large commercial buildings • Light industrial applications • Computer room and regional data centers • Healthcare, Telecommunication, Transportation, Financial, Government • Non-IT 14 Overview Easy UPS 3L 250-600 kVA (400V) is an easy to configure, use, and service 3-Phase UPS that delivers high availability and predictability to medium and large commercial buildings and light industrial applications. SE.com Features • Easy deployment and compact footprint • Delivers up to 96% efficiency • Power Module for fault-tolerant design • Streamlined installation and service • Protection against harsh environments with robust electrical specifications and ruggedizing features, including conformal coating • Replaceable dust filter • 1+1 redundant UPSs can share a common battery bank, reducing battery costs • IP20 (extra protection with IP31 option kit) • Smart Test mode optimizes site acceptance testing costs without requiring a load bank • Parallel up to 5 UPSs for capacity or 5+1 UPSs for redundancy • Supports 4+4 redundant configurations • Top cable entry • EcoStruxure connected • Embedded NMC with Secure NMC Subscription License • Start-up service included Options • Maintenance Bypass Panel • Classic Battery Cabinets • Empty battery cabinets • Battery Breaker Box and Battery Breaker Kit • Cold Start kit • Lithium-ion battery option Public 15 Galaxy 3L For external batteries: 250-600 kW (400V) Sold: China Features Applications & Segments • Medium and large data centers, and colocation facilities • Commercial and light industrial applications • Edge applications and computer rooms • Telecommunication, Healthcare, Government Transportation, Manufacturing, Finance • Easy deployment and compact footprint • Delivers up to 96% efficiency • Fault-tolerant design • Protection against harsh environments with robust electrical specifications and ruggedizing features • 1+1 redundant UPSs can share a common battery bank, reducing battery costs • Top cable entry • Replaceable dust filter • Embedded Network Management Card • IP20 (extra protection with IP31 option kit) • Smart Test mode optimizes site acceptance testing costs without requiring a load bank • Parallel up to 5 UPSs for capacity or 5+1 UPSs for redundancy • Supports 4+4 redundant configurations • 7-inch display • EcoStruxure connected • Start-up included Options • Maintenance Bypass Panel • Battery Breaker Box and Battery Breaker Kit • Classic Battery Cabinets • Empty battery cabinets • Cold Start kit 15 Overview Galaxy 3L 250-600 kVA (400V) is an easy to configure, use, and service 3-Phase UPS that delivers high availability and predictability to medium and large data centers, commercial buildings, and light industrial applications in China. SE.com • Bottom entry Cabinet • Lithium-ion battery option Public 16 Easy UPS 3-Phase Modular For external batteries: 50-250 kW (400V) Sold: All IEC countries worldwide, except Japan and China 16 Overview Easy UPS 3-Phase Modular 50-250 kW (400V) delivers robust power protection and availability in a capital- expenditure-friendly package. It is easy to select, quote, install, and maintain, with modular, redundant, scalable options and Live Swap modules in a compact footprint. SE.com Features Applications & Segments • Easy to select, configure, start up, use, and service • Up to 96% efficiency in double conversion mode • Third-party verified Live Swap functionality for fast MTTR and expansion with no scheduled downtime • Add Live Swap power modules as demand grows • Modular design with 50 kW power module enables N+1 redundancy to increase availability • Scalable design: pay as you grow • Up to 250 kW N+1 in a black one-rack design to conserve valuable real estate • Unity power factor @40°C • EcoStruxure connected for peace of mind anytime, anywhere • Parallel 4+0, increasing power capacity to 1 MW • Neutral Lithium-ion Function • Start-up service included • Bottom Entry Cabinet • Empty Battery Cabinet • Battery Breaker Box and Battery Breaker Kit • Maintenance Bypass Panel • Parallel Communications Kit • Redundant Intelligence Module • Lithium-ion battery option • Classic Battery Cabinet • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License • Other options: Depth Adapter, Backfeed Kit, Wide Seismic Kit, Battery Temperature Sensor • Small and medium data centers • Telecommunication • Transportation • Healthcare • Process Automation Options • Commercial buildings • Retail Public 17 Galaxy PX UPS 100-250 kW (400V) Sold: China Features Applications & Segments • Simple to select, configure, start up, use, and service • Up to 96% efficiency in double conversion mode • Third-party verified Live Swap functionality for fast MTTR and expansion with no scheduled downtime • Compact footprint with 10-inch touchscreen display • Modular design with 50 kW power module enables N+1 redundancy to increase availability • Parallel 4+0, increasing power capacity to 1 MW • Up to 250 kW N+1 in a black one-rack design to conserve valuable real estate • Scalable design: optimize capex, pay as you grow • Unity power factor @40°C • EcoStruxure connected for peace of mind anytime, anywhere • Neutral Lithium-ion Function • Start-up service included Options • Bottom Entry Cabinet • Depth Adapter • Neutral Disconnection Kit for 250 KW • Battery Temperature Sensor • Parallel Communications Kit • Lithium-ion battery option • 600mm wide Seismic Kit for 250 kW • Backfeed Kit 250 kW • Network Management Card • Redundant Intelligence Module 17 Overview Galaxy PX 100-250 kW (400V) UPS delivers robust power protection and availability in a capital-expenditure- friendly package. It is simple to select, quote, install, and maintain, with modular, redundant, scalable options, and Live Swap modules in a compact footprint. SE.com • Small & medium data centers • Telecommunication • Transportation • Healthcare • Process Automation• Commercial buildings • Retail Symmetra PX 400V: 16-500 kW with Symmetra PX 48 All-in-One, 96/160, & 250/500 208V: 10-100 kW with Symmetra PX 20, 40, & 100 480V: 100-500 kW with Symmetra PX 100 & 250/500 Sold: Worldwide 250/500 20 40 48 AIO 96/160 100 250/500 18 SE.com Features Applications & Segments • Data closet • Small, medium, and large data centers • Line up and match NetShelter form factor • Configurable for N+1 internal redundancy • Redundant intelligent modules • Scalable power capacity • Modular power, battery, bypass, and intelligent control modules • Parallel up to 4 UPSs (Symmetra PX 250/500 only) • Dual mains input, top or bottom feed • Embedded power distribution (PX20, 48) • EcoStruxure connected • Network Management Card with Secure NMC Subscription Licenses • Start-up service included Options • Secondary network management card (HTTP/Telnet/SNMP) • Seismic kits (OSHPD) • Battery breaker enclosure Overview Symmetra PX is a high performance, right-sized, modular, scalable, 3-phase UPS that offers power protection with high availability and efficiency for small, medium, and large data centers and mission-critical environments. Made up of dedicated and redundant modules, this architecture can scale power and runtime as demand grows or as higher levels of availability are required. • Extended runtime battery frames • Classic battery cabinets: PX100, 96/160, 250/500 • Lithium-ion battery option for Symmetra PX 250/500 • High-density zones of large data centers • Mission-critical environments • Maintenance bypass cabinets with distribution: PX40, 100, 96/160, 250/500 • Configurable power distribution: PX20, 40, 100 • Modular power distribution: PX48, 96/160, 100 Public 19 Galaxy PW 2nd Gen Features Applications & Segments • Petroleum Petrochemical Gas • Metallurgy • Power Plant • Medical • Semiconductor • Transportation • Food & Beverage • Mining • Manufacturing • Supports dual input • Overload capacity: 125% 10 min; 150% 1 min • Parallel up to 3+1 (4+0) • ISTA 2B • Robust design for harsh environments • Phase rotation check • Standard protection class: IP31 • Operating temperature: 0-40°C • Supports DC cold start • Designed for easy service • Start-up service included Options • AP9547 Network Management Card with Secure NMC Subscription License • Replaceable dust filters • Parallel Communications Kit • Backfeed Kits 19 10-200 kVA (400V) transformer-based UPS Sold: Europe, Middle East & Africa, Pacific, and Greater China Overview Galaxy PW 2nd Gen is a 10-200 kVA (400V) transformer-based UPS for industrial applications. The DC busbar voltage covers 220VDC and 384VDC, and uses a reliable 6-pulse or 12-pulse SCR rectifier. SE.com • Cable Adapter Kits for Galaxy Pwi • IP42 Kit (ETO) Products 3-phase UPSs Products 3-phase Lithium-ion Battery Cabinets 20 Public 21 Galaxy Lithium-ion Battery Cabinets Features Applications & Segments • Data centers, colocation, computer rooms • Edge computing, Internet DC, cloud computing • Computer rooms • Light industrial and commercial buildings • Infrastructure and transportation • Telecommunications and networking • Critical power infrastructures • Emergency lighting • UP9540A fire tested compliance • 67Ah LMO/NCM battery system • Double your battery life vs. VRLA solutions • Up to 70% more compact footprint frees up floor space for revenue-generating equipment • Boost availability with 2-3x faster recharge rates than VRLA solutions • Built-in 3-level battery management system (BMS) • Green Premium solution • Aesthetic match with Galaxy V Series UPSs • Self feeding SMPS simplifies installation • Fast, simple installation — cabinet ships pre- assembled, except battery modules, and rolls quickly into place • Enhance employee protection with modular touch- safe design, breaker covers, and built-in fuse protection at the battery cell and cabinet level • Seismic kit • EcoStruxure connected • Start-up service options available 21 For Galaxy VS, VM, VL, VX, VXL; Symmetra PX 250/500; Symmetra MW; Easy UPS 3M; Easy UPS 3L/Galaxy 3L; Easy UPS 3-Phase Modular; and Galaxy PX Sold: Worldwide Overview A Galaxy Lithium-ion Battery Cabinet are compact, lightweight, long-lasting, and sophisticated energy storage solution for Galaxy V series and Easy 3-phase UPSs in data centers, industrial processes, and critical infrastructures. This UL9540A-compliant battery solution reduces battery footprint and weight by up to 70%, allowing more effective use of space. Lithium-ion batteries reduce total cost of ownership, both by doubling battery life and by operating at higher temperatures, reducing cooling requirements. SE.com 22 Products 3-phase IT Power Distribution Public 23 Power Distribution Units (PDUs) Features Applications • Small, medium, and large data centers • Colocation facilities • Compartmental design simplifies asset access allocation • Meets the demanding scalability needs of any data center of any size • Factory installed and tested Square D breaker panel configured to meet the unique needs of your site • Easy to install and service with top and bottom cable entry • Low total cost of ownership • Seismic cabinet (OSHPD) • 7-inch display interface • EcoStruxure connected 23 Overview Power Distribution Units are reliable, scalable, and intelligent high-density power distribution solutions ideal for installation in the electrical rooms of data centers. SE.com 400 & 500 kVA (480V) Sold: US, Central America Options • Copper or aluminum transformers • Main input switch or breaker • Main output breaker • Advanced metering • Wide range of 250 Amp, 400 Amp, and 600 Amp branch breaker options from Schneider Electric's PowerPact J- and L-frame breaker series • EPO • Cloud service providers • Industrial applications 400 & 500 kVA (Aluminum) and 400 kVA (Copper) 500 kVA (Copper) Public 24 Galaxy RPP Features Applications • Data centers • Colocation facilities • Cloud service providers • Compact footprint and easy front-access design • Supports installation against walls, back-to-back, or in your EcoStruxure Pod Data Center • Flexible configuration, with factory installed and tested Square D breaker panels configured to your site requirements • Meets the demanding scalability needs of any large data center • PowerLogic Branch Circuit Power Meter monitors single or dual feed installations • Compartmental design simplifies asset access allocation • Top and bottom cable entry • Compatible with all Schneider Electric Power Distribution Units • 7-inch touchscreen display • EcoStruxure connected 24 Overview Galaxy RPP (Remote Power Panels) 250 and 400 Amp (120V/208V) offers highly configurable, highly modular, high-density row-level power distribution for data centers and colocation facilities. SE.com 250 & 400 Amp (120V/208V) Sold: US, Canada, Central America Options • L-frame or J-frame main input breakers • NP, NQ, or IP2X panelboard • QO, QOB, or EDB distribution breakers • Surge protection devices • Start-up service options available Configurable and Modular Power Distribution Units • Top or bottom cable entry (60/150 kW PDU) • Flexible configure-to-order options • Factory assembled and tested • Scalable • Modbus supported • Integrated monitoring • Network enabled • No side access required • Preconfigured cord sets • Compatible with StruxureWare Data Center Expert • Branch circuit monitoring • Power distribution modules with locking connectors (Modular) 25 Features Applications • Small, medium, or large data centers Overview Modular Power Distribution Units (PDUs) mitigate the need to predict the future requirements and configurations of your data center. Configurable Power Distribution Units bring agility, availability, and speed of deployment to your data center. Our factory-tested power distribution units are built to your exact specifications, support overhead or underfloor distribution, and feature a convenient, portable rack form factor. Options 120/208/230/400/480/600V: 72-277 kW (Modular) 208V/480V/600V: 40-150 kW (Configurable) Sold: Worldwide; product availability varies by region Modular Configurable • Shielding troughs Startup service SE.com: Configurable and Modular Upsilon Static Transfer Switches 30-630A standard; 800-1250A on request Sold: All IEC regions worldwide • Industrial applications • Data centers • Telecommunication centers • Infrastructure • Simplifies installation and maintenance while minimizing space requirements • Independent control boards, dual cooling systems, and power supplies ensure high reliability performance • Small footprint reduces required floor space • Text and mimic diagrams display modes of operation, system parameters, and alarms • Allows isolation of a source for maintenance without interrupting power to the protected loads Options • Communication: JBus/Modbus card (supplied as standard), status information card (supplied as standard) • Open frame version Overview Upsilon Static Transfer Switches (STS) provides true redundance and exceptional high reliability for automatic power supply transfer to a range of equipment from two independent and redundant power sources. Static Transfer Switches automatically transfer power to a stable alternate source in less than 4ms under normal operating conditions. Even under extreme conditions, such as 180 degrees out of phase, the STS will have detection and automatic transfer times that are up to 10 times faster than many other switches. 26 SE.com • PDU (36 16A circuit breakers incorporated in the H = 1900 cell, up to 100 A) • Connection at the top of the unit Features Applications & Segments 27 Key Applications and Segments by Product 28 IT Small data centers Medium data centers Large data centers Colocation

facilities Cloud computing Commercial facilities Industrial facilities Healthcare Transportation Telecommunications Energy & Chemical Metal, Minerals, and Mining Consumer Packaged Goods Semi Conductor Galaxy VS Galaxy VM Galaxy VL Galaxy VX Galaxy VXL Easy UPS 3S Easy UPS 3M Easy UPS 3M Advanced Easy UPS 3L Galaxy 3L Easy UPS
3-Phase Modular Galaxy PX Symmetra PX Galaxy PW 2nd Gen Galaxy Lithium-ion Battery Cabinets Power Distribution Units (PDUs) Galaxy RPP Configurable and Modular PDUs Upsilon Static Transfer Switches ü
ü Key Applications and Segments by Product To learn more about Schneider Electric 3-Phase UPS products and solutions, contact your
Schneider Electric representative or visit www.se.com. Schneider Electric 35 rue Joseph Monier 92500 Rueil Malmaison France ©2024 Schneider Electric. All Rights Reserved. Schneider Electric | Life Is On, Galaxy, and EcoStruxure are trademarks and the property of Schneider Electric SE, its subsidiaries, and affiliated companies. All other trademarks
are the property of their respective owners. Product specifications are subject to change without notice and are provided "as is" without warranty of any kind, express or implied. See apc.com for the most up to date product specifications. • 998-19858418_GMA-US 28 General 05/2024 EcoStruxure™ Power for Semiconductor Fabs Utilizing a Digital Twin for
Electrical Distribution to Drive Efficient Facilities Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Purpose of the Document Target
Audience This document is intended to address End User Engineering, Operations and Maintenance, Consultants, EPCs (Engineering, Procurement, and Construction) and Service teams and other qualified personnel. Objective To understand the challenges of designing and operating a Semiconductor Fab with an efficient and sustainable electrical
distribution strategy. Table of Contents Overview of capabilities Previous Next Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY
Table of Contents SECTION 1: Introduction to the Semiconductor Fab Introduces the context and the challenges of a Semiconductor Fab. SECTION 2: How Schneider Electric Can Support the Semiconductor Fab Industry with EcoStruxure Power Describes the solutions that EcoStruxure Power provides for Semiconductor Fabs, with typical electrical and
digital architectures. BIBLIOGRAPHY Contains useful documents to find out more about capabilities. Provides details about Green Premium. SECTION 3: Digital Solutions and Services Gives information about EcoStruxure Power capabilities for Semiconductor Fabs, sorted by value proposition: • Transverse Lifecycle Capabilities • Capabilities to Improve
Time To Market • Capabilities to Increase Efficiency • Capabilities to Improve Resiliency • Capabilities to Grow Sustainability Reference Guide EcoStruxure™ Power for Semiconductor Fabs General WHY READ THIS SECTION? SECTION 1 SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry
SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Semiconductor Fab Industry Semiconductor Fab Industry Challenges The objective of this section is to: • Introduce the growth, trends and challenges of the Semiconductor Fab industry • Present the 4 pillars to meet the Semiconductor Fab challenges.
Introduction to the Semiconductor Fab Industry Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY SECTION 1 – Introduction to the Semiconductor Fab Industry Semiconductor Fab Industry
Semiconductor Fab Industry Challenges Semiconductor Fab Market An industry driven by the growth of new technology Sources Chip Shortages Continue 17% Annual growth in chip demand from 2020-2022, while supply grew at only 6% per year. Strong Robust Growth +7% Robust growth till 2030. Hunt for Talent Intensifies +77% Rise in chip-related job
vacancies from 2020. Geopolitical Impacts 65% Global share of value chain activities based in Asia, creating high supply chain risk. Focus on Sustainability +36% Semiconductor companies reinforced ESG* practices (2021 reporting). Acceleration of Digital Transformation +52% Increased use of cloud / automation in 2021. * ESG = Environmental, Social,
and Governance Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY SECTION 1 – Introduction to the Semiconductor Fab Industry Semiconductor Fab Industry Semiconductor Fab Industry
Challenges Strong Robust Growth: https://www.mckinsey.com/industries/semiconductors/our-insights/the-semiconductor-decade-a-trillion-dollar-industry Hunt for Talent Intensifies: https://asia.nikkei.com/Business/Business-Spotlight/Chip-talent-war-Taiwan-faces-critical-staffing-shortage Focus on Sustainability: https://arstechnica.com/science/2022/04/can-
semiconductor-makers-meet-surging-demands-sustainably/ Geopolitical Impacts: https://www.voanews.com/a/race-for-semiconductors-influences-taiwan-conflict-/6696432.html Acceleration of Digital Transformation: https://quixy.com/blog/top-digital-transformation-statistics-trends- forecasts/
#:~:text=According%20to%20Markets%20and%20Markets,by%205.1%25%20according%20to%20Gartner. Chip Shortages Continue: https://www.mynewsdesk.com/rolandberger/pressreleases/global-semiconductor-shortage-to-persist-for-several-years-beyond- 2022-3151267 Sources Reference Guide EcoStruxure™ Power for Semiconductor Fabs
General SECTION 3 – Digital Solutions and Services SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY SECTION 1 – Introduction to the Semiconductor Fab Industry Semiconductor Fab Industry Semiconductor Fab Industry Challenges Semiconductor Fab Market The market trends: a changing landscape
Significant investment for expansions and modernization A growing focus on efficiency and sustainability High demand for power and water to meet semiconductor production capacity Cybersecurity Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 2 – How EcoStruxure Power
Can Support the Semiconductor Fab BIBLIOGRAPHY Semiconductor Fab Industry Semiconductor Fab Industry Challenges SECTION 1 – Introduction to the Semiconductor Fab Industry How can we reduce our operational costs? How can we improve power quality and minimize downtime? How can we reduce our carbon footprint and integrate more
renewable, sustainable energy sources? How can we accelerate the design & build of new semiconductor fabs? Semiconductor Fab Industry Challenges Four pillars to drive efficiency, resiliency and sustainability KPIs The strong growth of the semiconductor industry leads to an increase in fabrication capacity. Creating or expanding this capacity is not
without its challenges. Four pillars must be addressed: Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General WHY READ THIS SECTION? SECTION 2 SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab
Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Solutions to Address the Four Pillars EcoStruxure Power Value Proposition Example of Electrical & Digital Architectures The objective of this section is to: • Present the solutions to address the four pillars to meet the Semiconductor Fab industry
challenges • Explain how Schneider Electric EcoStruxure Power can support this industry • Give an example of electrical and digital architectures. How EcoStruxure Power Can Support the Semiconductor Fab Industry Reference Guide EcoStruxure™ Power for Semiconductor Fabs General EcoStruxure Power Value Proposition Example of Electrical &
Digital Architectures Solutions to Address the Four Pillars SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Solutions to
Address the Four Pillars of Semiconductor Fabs The four pillars can be addressed by the following solutions: Improve Facility Performance Minimize Downtime Meet Sustainability KPIs Use Standardized Architectures Use standardized electrical distribution and digital tools to speed up the design, build and commissioning of new fabs. Turn data into
business intelligence and leverage a digital twin to provide actionable insights to drive efficiency. Help assure optimum power quality and reliability while improving safety for your staff and guarding against cyber attacks Engage consultancy services to strategize, digitize and decarbonize. This guide describes the solutions developed by EcoStruxure Power
to address these four pillars. Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab Example of Electrical & Digital Architectures Solutions to Address the Four Pillars EcoStruxure Power Value
Proposition SECTION 3 – Digital Solutions and Services BIBLIOGRAPHY EcoStruxure Power Value Proposition EcoStruxure Power for Semiconductor Fabs We are your end-to-end digital partner to design, build, operate and maintain semiconductor fabs with the utmost efficiency and resiliency towards a sustainable future. From electrical design to
operations and maintenance Our collaborative environments, enhanced by the Electrical Distribution Digital Twin of your fab, enable high productivity operations. Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the
Semiconductor Fab Solutions to Address the Four Pillars EcoStruxure Power Value Proposition Example of Electrical & Digital Architectures SECTION 3 – Digital Solutions and Services BIBLIOGRAPHY Example of Electrical and Digital Architectures Typical front-end Semiconductor Fab Energy is key, whether for processes or for utilities: specific attention
must be given to the design of the electrical architecture and associated digital architecture which will enable digital solutions and services. Front-end Semiconductor Fab PROCESS 50 % UTILITIES 50 % Ultrapure Water (UPW) Diffusion Photolithography Etching Ion Implantation 1 2 1 2 Subfab Cleanroom Others Clean Dry Air (CDA) and N2 Exhaust
System Cooling Water System Physical Vapor Deposition (PVD) / Chemical Vapor Deposition (CVD) Chemical Mechanical Planarization (CMP) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab
Solutions to Address the Four Pillars EcoStruxure Power Value Proposition Example of Electrical & Digital Architectures SECTION 3 – Digital Solutions and Services BIBLIOGRAPHY Example of Electrical Architecture Example of Electrical and Digital Architectures Typical electrical architecture for a Semiconductor Fab General Example of Electrical
Architecture UTILITY 50 % Cooling Water System • Chilled Water (MV Chillers, Cooling Towers) • Process Cooling Water (PCW) • AHU, FCU, FFU, Dry Coil Exhaust System Clean Dry Ari (CDA) and N2 Ultrapure Water (UPW) Others • Lighting • Wastewater • Air Recirculation • Make-Up Air Unit • Bulk Gases • Automated Materials Handling System
(AMHS) • Abatement PROCESS 50 % Critical Process = Power Availability High Energy demand = Efficient Energy Management Diffusion Photolithography Etching Ion Implantation Chemical Mechanical Planarization (CMP) Physical Vapor Deposition (PVD)/ Chemical Vapor Deposition (CVD) Reference Guide EcoStruxure™ Power for Semiconductor
Fabs General SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab Solutions to Address the Four Pillars EcoStruxure Power Value Proposition Example of Electrical & Digital Architectures SECTION 3 – Digital Solutions and Services BIBLIOGRAPHY Example of
Electrical and Digital Architectures Suggested digital architecture (high-level view) for a Semiconductor Fab Example of Digital Architecture (High-Level View) General Example of Digital Architecture (High-Level View) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 1 – Introduction to the Semiconductor Fab Industry
SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab Solutions to Address the Four Pillars EcoStruxure Power Value Proposition Example of Electrical & Digital Architectures SECTION 3 – Digital Solutions and Services BIBLIOGRAPHY Example of Electrical and Digital Architectures Corresponding detailed digital architecture for a
Semiconductor Fab Example of Digital Architecture (Detailed View) General Example of Digital Architecture (Detailed View) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General WHY READ THIS SECTION? SECTION 3 SECTION 3 – Digital Solutions and Services Introduction Overview of Digital Solutions and Services Transverse
Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Resiliency Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY This section gives information
about EcoStruxure Power capabilities for Semiconductor Fabs aligned to the industry challenges. Digital Solutions & Services Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Introduction SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure
Power Can Support the Semiconductor Fab BIBLIOGRAPHY Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Grow Sustainability Improve Resiliency Increase Efficiency Improve Time
to Market Introduction EcoStruxure Power provides capabilities to support the challenges of Semiconductor Fabs throughout their lifecycle These capabilities provide standardized designs and digital architectures, and enable easy simulation, to reduce cost of design and ownership. These capabilities use digitization to provide intelligent information to the
workforce, allowing them to make smart decisions that reduce operating costs and increase efficiency. These capabilities use digitization to reduce unplanned downtime, increase reliability, and thus reduce production waste. These capabilities help track energy consumption and carbon emissions to meet sustainability requirements. Design, Build,
Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities Digital Solutions that support your project from the Design, Build, Commission to Operate & Maintain phases. Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and
Services Overview of Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve
Resiliency Capabilities to Grow Sustainability Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance
Greenhouse gas reporting + + + Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities Asset performance Power quality monitoring and compliance Thermal and partial
discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation
Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Power system study+ Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities
SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry
Transverse Lifecycle Capabilities Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Transverse Lifecycle
Capabilities Asset performance Power quality monitoring and compliance Thermal and partial discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ AC&DC electrical network bus design and
simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Power system study Grow Sustainability Improve Resiliency Increase
Efficiency Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How EcoStruxure Power Can Support
the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry Electrical Digital Twin Benefits • Intelligent user-
interface for all levels of AC and DC networks • Enables users, from the design to operate phases, to model, simulate, analyze and validate electrical power systems to predict their electrical network behavior • Takes the day-to-day system modeling and design tasks to a new level of speed, accuracy and ease Maintain a Digital Twin of your electrical
distribution Transverse Lifecycle Capabilities Electrical Digital Twin Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions
and Services Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry Green Premium Benefits • Green Premium* products provide detailed information on their regulatory compliance, material content,
environmental impact, and circularity attributes. Manage sustainability from design to end of life Transverse Lifecycle Capabilities Compliance and transparency (compliance certificates, circularity profiles, environmental footprint, etc.)1 Circular performance Durability, upgradeability, re-manufacture, recycled content, recyclability Well-being performance
E.g. free of PVC, mercury, silicone, SVHC, lead, toxic heavy metal and compliant with California Prop 65 4 Resource performance Optimized energy performance Lower carbon emissions 2 3 * The Green Premium label was created to provide Schneider Electric's customers with more sustainable products and to be transparent with environmental
information. Supporting your efforts for a LEED certified building Helping you achieve Living Building Challenge certification Green Premium Value Proposition Learn more about: • Green Premium Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities
SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry
Cybersecurity Benefits • Provides a selection of cybersecurity certified products • Provides certified system architectures and solutions • Delivers lifecycle services Help secure the digital power distribution system Transverse Lifecycle Capabilities Learn more about: • Cybersecurity Certified products developed according to IEC 62443 functional
requirements with Secure Development Lifecycle processes. Consulting services from design, implementation, operations and maintenance to tailor your security solutions to your strategy and budget. Lifecycle services Certified secure system architecture according to IEC 62443-3-3 with documented processes and solutions for a secure system.
Cybersecurity system configuration software for consistent security policy deployment. Certified products Certified systems & solutions Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry
SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Capabilities to Improve Time to Market Electrical Digital Twin Green
Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Transverse Lifecycle Capabilities Asset performance Power quality monitoring and
compliance Thermal and partial discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction Simulate before Operate Arc flash protection + + + + + + + + + AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load
flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & Microgrid energy storage sizing simulation + + + + + + + + Power system study+ Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Design, Build, Commission
(Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can
Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability AC and DC Electrical Network Bus Design and Simulation Primary Department • Design • Construction Benefits •
Single solution/environment - Unified AC & DC solution from HV to LV - One unique platform and one database • Efficient profile management - User-defined loading and generation profiles - External data profile based on field measurements • Scalability - Load growth study for future planning • Event simulations within the calculation period Optimize bus
design allocation and simulation ETAP Electrical Network Model Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure
Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Electrical Network Short Circuit Simulation Primary Department • Design • Construction Benefits •
Expedite design studies with a wide range of calculation scenarios, including advanced fault analysis - IEC & ANSI duty calculation for balanced and unbalanced faults - Simultaneous fault at selected nodes - Inclusive 3-Phase and 1-Phase fault analysis - Pre-Fault system loading consideration Design and simulate unbalanced short circuits Electrical
Network Short Circuit Simulation in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support
the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Network Load Flow and Voltage Drop Simulation Primary Department • Design • Construction Benefits • Simulation of bus
voltages, branch power factors, currents, system losses, power generation versus loading • Use of ETAP Electrical Digital Twin model with powerful calculation engines and user-friendly interface • Simulation using multiple loading and generation conditions Perform power flow analysis and voltage drop calculations Network Load Flow and Voltage Drop
Simulation in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab
BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Device Coordination and Selectivity Primary Department • Design • Construction Benefits • Verified and validated libraries • Graphically adjustable
device settings • Detailed device settings reporting • Continuous synchronization with one-line and integrated equipment database Automatically detect and evaluate the system protection and coordination/selectivity Device Coordination and Selectivity in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for
Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle
Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Arc Fault Protection and Coordination Primary Department • Design • Construction Benefits • Evaluate, verify, and confirm the operation and selectivity of the protective devices for various types of faults for any location directly from the
single-line diagram • Animation displayed on the single-line diagram • 3-phase / 1-phase sequence of operation Perform sequence of operation for arc fault and bolted fault Arc Fault Protection and Coordination in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital
Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities
to Improve Resiliency Capabilities to Grow Sustainability Power Quality Simulation and Modeling Primary Department • Design • Construction Benefits • Simulate harmonic current and voltage sources: - To identify potential harmonic problems (report of harmonic voltage and current distortion limit violations) - To identify the need for a harmonics filter •
Simulate and analyze the size of the harmonics filter your system will need to optimize performance and reduce nuisance trips Evaluate and validate distortion due to harmonics Power Quality Simulation and Modeling in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 –
Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency
Capabilities to Improve Resiliency Capabilities to Grow Sustainability Renewable and Microgrid Energy Storage Sizing Simulation Primary Department • Design • Construction Benefits • Build renewable energy models combined with full spectrum power system analysis calculations for: - Accurate simulation - Predictive analysis - Equipment sizing - Field
verification of wind, solar farms and other DERs • Enable designers and engineers to conceptualize the collector systems, determine wind penetration and perform grid interconnection studies Design and optimize the microgrid system Microgrid Energy Storage Sizing Simulation in ETAP Capabilities to Improve Time to Market Reference Guide
EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services
Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Power System Study Primary Department • Design • Construction • Facilities Electrical Department Benefits • Partner with a global team of experts, engaged with industry standards committees, to develop common
safety standards and practices. • Create a standardized approach to Power System Studies to support multisite deployments with consistent results Work with engineering experts to provide Power System Studies Study (Analyze) Assess Design Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs
General SECTION 3 – Digital Solutions and Services Capabilities to Increase Efficiency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to
Improve Time to Market Capabilities to Improve Resiliency Capabilities to Grow Sustainability Capabilities to Increase Efficiency Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting
services Energy efficiency compliance Greenhouse gas reporting + + + Transverse Lifecycle Capabilities Asset performance Power quality monitoring and compliance Thermal and partial discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction Arc flash
protection Simulate before Operate + + + + + + + + + AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing
simulation + + + + + + + Power system study Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and
Services Capabilities to Increase Efficiency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve
Resiliency Capabilities to Grow Sustainability Operator Training Simulation Primary Department • Facility Operations & Maintenance Benefits • Practice operation within a simulated but highly realistic environment to enhance safety and operational efficiency • Track and review trainee actions to analyze and challenge them Train new employees and build
confidence on new systems + Capabilities to Increase Efficiency Principle of Operator Training Simulation Application Learn more about: • Operator Training Simulation (IEC / NEMA) Operator Training Simulation Reference Architecture General Operator Training Simulation Reference Architecture Reference Guide EcoStruxure™ Power for
Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Increase Efficiency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities
Capabilities to Improve Time to Market Capabilities to Improve Resiliency Capabilities to Grow Sustainability Energy Monitoring and Usage Analysis Primary Department • Facility Operations & Maintenance Benefits • Bring awareness to utility consumption - Turn data into easy-to-interpret graphical dashboards and reports to raise awareness amongst key
stakeholders • Identify "quick-win" opportunities for energy savings - By comparing and visualizing energy usage and cost for different utilities over different time periods - By identifying and prioritizing which areas lend themselves to a high energy-saving return on investment Determine where to focus energy conservation initiatives Capabilities to Increase
Efficiency Energy Usage Analysis Dashboards in EcoStruxure Power Operation Learn more about: • Energy Monitoring (IEC / NEMA) Energy Monitoring and Usage Analysis Reference Architecture General Energy Monitoring and Usage Analysis Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3
– Digital Solutions and Services Capabilities to Increase Efficiency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market
Capabilities to Improve Resiliency Capabilities to Grow Sustainability Energy Performance, Modeling and Verification Primary Department • Facility Operations & Maintenance Benefits • Provide energy usage information based on equipment and processes • Compare model versus actual consumption • Compare pre-retrofit versus post-retrofit energy
consumption to track improved performance and savings as a result of energy conservation initiatives Analyze the energy performance of a plant against a model baseline Capabilities to Increase Efficiency Energy Performance, Modeling and Verification Output in EcoStruxure Power Operation Energy Performance, Modeling and Verification Reference
Architecture Learn more about: • Energy Performance (IEC / NEMA) • Energy Modeling and verification (IEC / NEMA) General Energy Performance Modeling and Verification Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Increase Efficiency
SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Resiliency Capabilities to Grow Sustainability
Capacity Management Primary Department • Facility Operations & Maintenance Benefits • Monitor electrical network capacity • Track and review capacity efficiency • Minimize downtime by tracking the capacity of transformers, circuit breakers, UPSs, generators, etc. Monitor the capacity of electrical distribution Capabilities to Increase Efficiency Breaker
Capacity Single-line Diagram in EcoStruxure Power Operation Capacity Management Reference Architecture Learn more about: • Capacity Management (IEC / NEMA) General Capacity Management Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities
to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to
Grow Sustainability Capabilities to Improve Resiliency Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + +
Transverse Lifecycle Capabilities Asset performance Power quality monitoring and compliance Thermal and partial discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ AC&DC electrical network
bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Power system study Grow Sustainability Improve
Resiliency Increase Efficiency Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to
the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Predictive Simulation Help
employees make better decisions Primary Department • Facility Engineering • Design Engineering Benefits • Reduce safety risks by practicing emergencies and high-risk situations • Enhance operational efficiency by running "what-if" scenarios • Provide faster analysis response to incidents Capabilities to Improve Resiliency + Predictive Simulation
Reference Architecture Principle of Predictive Simulation Application General Predictive Simulation Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 –
How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Simulate Before Operate Empower operators with predictive outcomes Primary
Department • Facility Operations & Maintenance Benefits • Provide operators with a list of potential side effects, prior to executing a command • Empower employees to feel more confident when operating their facilities by providing real time guidance • Reduce human error that could lead to outages or safety concerns Capabilities to Improve Resiliency +
Simulate Before Operate Reference Architecture Principle of Simulate before Operate Application Learn more about: • Simulate Before Operate (IEC / NEMA) General Simulate Before Operate Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to
Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to
Grow Sustainability Electrical Distribution Monitoring and Alarming Monitor and control electrical network Primary Department • Facility Operations & Maintenance Benefits • Show real-time status of the power distribution • Customized single-line diagram • 24/7 power monitoring and alarm notification Capabilities to Improve Resiliency Electrical Distribution
Monitoring and Alarming Single-line Diagram in EcoStruxure Power Operation Electrical Distribution Monitoring and Alarming Reference Architecture Learn more about: • Electrical distribution monitoring and alarming (IEC / NEMA) • Power Source and Load Control (IEC / NEMA) General Electrical Distribution Monitoring and Alarming Reference
Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital
Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Power Events Analysis Analyze the root causes of electrical events Primary Department • Facility Operations & Maintenance Benefits • Automatically classifies and describes any electrical
events • Uses system intelligence to determine root cause and location of events • Shows context and sequence of events using the timeline analysis interface Capabilities to Improve Resiliency Event and Alarm Status view in EcoStruxure Power Operation Event and Alarm Status Timeline in EcoStruxure Power Operation Power Event Analysis Reference
Architecture Learn more about: • Power Event Analysis (IEC / NEMA) General Power Events Analysis Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 –
How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Asset Performance Benefit from a strategic maintenance approach Primary
Department • Facility Operations & Maintenance Benefits • Move from reactive or preventive to condition-based (predictive) maintenance strategies for critical assets like circuit breakers, gensets, transformers, etc. • Provide event details and notification to the operator if a protection setting has been changed • Receive notifications and diagnostics reports
from expert service engineers with recommendations to optimize maintenance by asset or site Capabilities to Improve Resiliency Asset Performance Reference Architecture Aging Diagram for Circuit Breakers in EcoStruxure Power Operation Gigafactory Learn more about: • Asset Performance (IEC / NEMA) General Asset Performance Reference
Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital
Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Power Quality Monitoring and Compliance Gain insights to improve power quality and comply with standards Primary Department • Facility Operations & Maintenance Benefits • Bring
awareness of power quality • Enhance operational efficiency by making sure clean power is fed to sensitive process equipment • Help protect sensitive equipment by tracking power quality problems before they arise Capabilities to Improve Resiliency Power Quality and Compliance Dashboards in EcoStruxure Power Operation Power Quality and
Compliance Report in EcoStruxure Power Operation Power Quality Monitoring and Compliance Reference Architecture Learn more about: • Power Quality Monitoring and Compliance (IEC / NEMA) General Power Quality Monitoring and Compliance Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION
3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market
Capabilities to Increase Efficiency Capabilities to Grow Sustainability Power Quality and Power Factor Correction Help protect sensitive equipment from power quality issues Primary Department • Facility Operations & Maintenance Benefits • Monitor sensitive process lines and busbars • Provide clean power to sensitive process equipment • Track Power
Quality problems to help avoid downtime • Reduce financial impact of power factor on energy bill Capabilities to Improve Resiliency Galaxy VM Power Quality Information in EcoStruxure Power Operation Before and After Power Quality and Power Factor Correction Implementation Power Quality and Power Factor Correction Reference Architecture Learn
more about: • Power Quality Correction (IEC / NEMA) • Power Factor Correction (IEC / NEMA) General Power Quality and Power Factor Correction Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to
the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Continuous Thermal Monitoring
& Partial Discharge Monitoring Help prevent electrical fires and help protect employees and equipment Primary Department • Facility Operations & Maintenance Benefits • Provide early detection of internal arcing or temperature abnormalities in equipment that can cause damage - To help reduce the risk of equipment and electrical room damage - To
improve service continuity • Enable optimized maintenance schedules by providing continuous monitoring vs calendar-based service Capabilities to Improve Resiliency Continuous Thermal Monitoring & Partial Discharge Monitoring Reference Architecture Learn more about: • Continuous Thermal monitoring (IEC / NEMA) Continuous Thermal Monitoring
in the Single-line Diagram of EcoStruxure Power Operation General Continuous Thermal Monitoring and Partial Discharge Monitoring Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the
Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Arc Flash Protection Help protect
employees and equipment Primary Department • Facility Operations & Maintenance Benefits • Help prevent loss of life and reduce the risk of equipment and electrical room damage • Improve maintenance team awareness to help troubleshoot and identify the root cause of arc flash events Arc Flash in a Switchboard Arc Flash Alert and Location in
EcoStruxure Power Operation Capabilities to Improve Resiliency Arc Flash Protection Reference Architecture Learn more about: • Arc Flash Protection (IEC / NEMA) General Arc Flash Protection Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to
Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to
Improve Resiliency Capabilities to Grow Sustainability Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + +
Transverse Lifecycle Capabilities Asset performance Power quality monitoring and compliance Thermal and partial discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ AC&DC electrical network
bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Power system study Grow Sustainability Improve
Resiliency Increase Efficiency Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to
the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Carbon Neutrality Consulting
Services Track and reduce carbon emissions to demonstrate the carbon neutrality of the company Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Get support from our consulting services to define your strategy for achieving carbon neutrality Capabilities to Grow Sustainability + Services Carbon neutrality Reduce
Carbon Emissions Produce Renewable Energy Purchase Renewables/Offsets Energy Efficiency • Sustainable building design & operations – HVAC Efficiency – Lighting Efficiency – Operational Efficiency Behind-the-Meter Renewables • Solar Panels / Heating • Wind • Geothermal Purchase Renewables • Renewable Power Purchasing Agreements (PPA) •
Renewable Energy Certificates (REC) • Biofuels Supporting Technologies • Microgrid with Smart Management • Battery Storage • Fuel Cells Purchase Offsets • Carbon Credits – Carbon Capture – Tree Planting 1 2 3 Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Grow
Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve
Resiliency Energy Efficiency Compliance Comply with standards related to energy management systems Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Report and show facility compliance to local sustainability requirements - To benefit from tax credits - To gain credibility to participate in new projects Capabilities
to Improve Sustainability EcoStruxure Power Operation Energy Star Compliance Dashboard EcoStruxure Resource Advisor Dashboard in EcoStruxure Power Operation Sustainable Organizations and Standards Energy Efficiency Compliance Reference Architecture Learn more about: • Energy Efficiency Compliance (IEC / NEMA) General Energy
Efficiency Compliance Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY
Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Greenhouse Gas Reporting Track and report carbon emissions Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Track
and report carbon emissions and waste (e.g., water) in one single place • Provide period-over-period usage comparison to detect a drift Capabilities to Improve Sustainability Greenhouse Gas Reporting Reference Architecture Learn more about: • Greenhouse Gas Reporting (IEC / NEMA) Greenhouse Gas Reporting and Dashboard Examples in
EcoStruxure Power Operation General Greenhouse Gas Reporting Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General Legal Information SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the
Semiconductor Fab BIBLIOGRAPHY Reference Documents BIBLIOGRAPHY Reference Guide EcoStruxure™ Power for Semiconductor Fabs General Legal Information BIBLIOGRAPHY Reference Documents SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power
Can Support the Semiconductor Fab Reference Documents Design Guide IEC EcoStruxure Power Design Guide Ref: ESXP2G001EN 02/2024 Digital Applications for Large Buildings and Critical Facilities The Digital Applications Design Guide provides comprehensive details on the building blocks of EcoStruxure Power: the IoT applications are driven by a
software layer to control the traditional electrical distribution infrastructure. Developed to help engineering consultants and designers, this guide is an invaluable resource for specifying, designing and prescribing EcoStruxure Power architectures capable of performing one or more of the business-driven applications described within. NEMA EcoStruxure
Power Design Guide Ref: 0100DB1802 01/2024 https://www.se.com/ww/en/downl oad/document/ESXP2G001EN/ https://www.se.com/us/en/download/ document/0100DB1802/ Web version PDF version Web version https://go.schneider- electric.com/WW_202004_Digital- Applications-for-Large-Buildings-and- Critical-Facilities_EA-LP.html PDF version
https://go.schneider- electric.com/WW_202004_Digital- Applications-Design-Guide_EA-LP.html Landing page: https://www.se.com/ww/en/work/campaign/innovation/power-digital-applications-design-guide.jsp Reference Guide EcoStruxure™ Power for Semiconductor Fabs General Legal Information SECTION 3 – Digital Solutions and Services SECTION 1
– Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Reference Documents Legal Information The information provided in this document contains general descriptions, technical characteristics and/or recommendations related to products/solutions. This document is
not intended as a substitute for a detailed study or operational and site-specific development or schematic plan. It is not to be used for determining suitability or reliability of the products/solutions for specific user applications. It is the duty of any such user to perform or have any professional expert of its choice (integrator, specifier or the like) perform the
appropriate and comprehensive risk analysis, evaluation and testing of the products/solutions with respect to the relevant specific application or use thereof. The Schneider Electric brand and any trademarks of Schneider Electric SE and its subsidiaries referred to in this document are the property of Schneider Electric SE or its subsidiaries. All other brands
may be trademarks of their respective owner. This document and its content are protected under applicable copyright laws and provided for informative use only. No part of this document may be reproduced or transmitted in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise), for any purpose, without the prior written
permission of Schneider Electric. Schneider Electric does not grant any right or license for commercial use of the document or its content, except for a non- exclusive and personal license to consult it on an "as is" basis. Schneider Electric reserves the right to make changes or updates with respect to or in the content of this document or the format thereof,
at any time without notice. To the extent permitted by applicable law, no responsibility or liability is assumed by Schneider Electric and its subsidiaries for any errors or omissions in the informational content of this document, as well as any non-intended use or misuse of the content thereof. AccuSine™, Acti 9™, Altivar™, ASCO™, BlokSeT™, ComPacT™,
EcoStruxure™, EnerLin'X™, ETAP™, EVlink™, EvoPacT™, Galaxy™, Harmony™, Iso-Gard™, Masterclad™, MasterPacT™, MicroLogic™, Modicon™, Okken™, PowerLink™, PowerLogic™, PowerPacT™, Power-Zone™, PremSeT™, PrismaSeT™, Schneider Electric™, SM AirSeT™, Square D™, SureSeT™, TeSys™, TransferPacT™, Trihal™,and
Vigilohm™ are trademarks and the property of Schneider Electric SE, its subsidiaries and affiliated companies. All other brands are trademarks of their respective owners 2024/05/28 ESXP2RG002EN PEP method for assessing 3-Phase UPS sustainability se.com Table of contents Life is On | Schneider Electric Introduction 1 Conclusion 5 Environmental declarations 2 UPS carbon footprint comparisons 3 UPS carbon calculation
tool 4 • Common errors to avoid when comparing UPSs • Steps for accurate UPS comparisons • What is a PEP and how to read it • Product specific rules (PSR) for 3-phase UPS • Carbon profile of a typical 3-phase UPS Life is On | Schneider Electric Introduction Life is On | Schneider Electric Introduction In White Paper 64, Why Data
Centers Must Prioritize Environmental Sustainability: Four Key Drivers, companies are seeking ways of decreasing their data center's environmental footprint and of their company in general. These needs apply to all data center sizes, from the largest multi-megawatt purpose-built data center to a single-rack micro data center in a branch office. Most
vendors recognize these needs and therefore promote their product's sustainability as a means to help their customers attain their sustainability goals. As one of the leading companies in demonstrating sustainability1 , Schneider Electric believes that customers care about three key topics when it comes to sustainable products: 1 Schneider Electric
recognized in Corporate Knights' Global 100 for the 12th year in a row 2 Sustainability data that is free and available to all customers and validates product claims, including documentation like environmental product disclosures and product end-of-life treatments. 3 Performance characteristics that improve a product's sustainability, including lower impact

materials, energy efficiency, durability, repairability, and take-back. 1 Compliance with applicable regulations, particularly those related to hazardous substances. Includes mandatory compliance to hazardous substance regulations such as the European directive for Restriction of Hazardous Substances (RoHS); European Regulation for Registration, Evaluation (REACh); European directive for Waste from Electrical and Electronic Equipment (WEEE); China RoHS; and California Proposition 65. Life is On | Schneider Electric Environmental declarations An environmental product declaration (EPD) summarizes the environmental life cycle data of a product or service and is normally valid for five years. These documents help specifiers make Uninterruptible Power Supply (UPS) decisions based on environmental impacts like carbon footprint and water use, making it easier to compare UPSs of the same category. The International Organization for Standardization (ISO) publishes the standards that underly EPDs, in particular ISO 14025. EPDs must be based on life cycle assessment (LCA) data or life cycle inventory analysis (LCI) data, which are governed by the ISO 14040 standard. For more information on ISO standards, see Schneider Electric White Paper 70. Note that ISO 14040 is generic and applies to all types of products and services. The following sections explain how to read an EPD, explain three key concepts of a 3-phase UPS PSR, and describe the typical carbon profile of a 3-phase UPS. Life is On | Schneider Electric Environmental declarations Program operators like the P.E.P. Association administer programs in compliance with ISO 14025 so that EPDs report the same type of information. They develop, approve, and publish product category rules (PCR) and product-specific rules (PSR) for Type III environmental declarations. All EPDs must be independently verified by internal2 or external experts and provide information need to track Scope 1, 2, and 3 3 emissions. For this e-guide, the PCR related to a UPS covers electrical, electronic, and HVAC-R products and defines how vendors should perform the LCA. When the PCR isn't detailed enough to develop EPDs for specific products, program operators develop PSRs. P.E.P. Association 11/17, rue de l'Amiral Hamelin - 75016 Paris Non-profit association (Law of 1901) – SIRET No.: 789 180 320 00010 PEP ecopassport® PROGRAM PCR Product Category Rules for Electrical, Electronic and HVAC-R Products PCR-ed4-EN-2021 09 06 © 2021 P.E.P. Association Copyright of PCR Product Category Rules are © PEP Ecopassport® Program property, if nothing else has been specified (e.g. the cross-publication of PCR from other programs). The use of the PCR for any other purpose than to develop PSRs and register PEPs in the International PEP Ecopassport® Program are subject to approval by the General Secretariat, which may be contacted at: contact@pep-ecopassport.org Reporting environmental data for a UPS 2 This applies to business-to-business products only. 3 See Appendix of White Paper 67, Guide to Environmental Sustainability Metrics for Data Centers, for information on Scope 1, 2, and 3. Life is On | Schneider Electric What is a PEP and how to read it PEP stands for Product Environmental Profile. The PEP Ecopassport association defines which mandatory information a PEP must provide. While the templates change from vendor to vendor, the key information needed for a UPS comparison is usually presented in the following order: 6 Verification information 5 Environmental impacts 4 Additional environmental information 3 Constituent materials 2 The "function" or "functional unit" 1 The "reference product" or "representative product" All values in the PEP are expressed in scientific notation using a decimal value with an exponential (E) of 10. In this example: 1.97E06 = 1.97 x 10E6 = 1.97 x 1,000,000 = 1,970,000 PEP contains the CO_2 emissions data of the product PEP Extract of a 3-phase UPS: Galaxy VX The 'Contribution to climate change' contains the CO_2 Emissions of the product expressed in kg CO_2 equivalent. Description of the different Life Stages of the product Life is On | Schneider Electric The PSRs define rules for specific products within the larger product category. Due to their unique function, such as multiple operating modes, UPSs are one of those products that require their own product specific rules. There are 3 key concepts in the UPS PSR that play a significant role in determining the life cycle carbon footprint of a UPS. 1. Reference Service Life (RSL) The RSL is the length of time the UPS is expected to remain in service. According to section 3.5.5.1 of the PSR, a 3-phase UPS over 10 kW has a service life of 15 years. This means that the life cycle assessment accounts for 15 years of UPS emissions. For example, if the electricity use emissions for the UPS is 100,000 kg CO_2 e per year, its lifetime electricity emissions would be 100,000 kg CO_2 e x 15 years or 1,500,000 kg CO_2 e. 2. Typical load profile A load profile is meant to ensure that all manufacturers use the same assumptions to calculate electricity use. A load profile includes % load, length of time a UPS operates during its lifetime, and UPS operating mode. For 3-phase UPSs greater than 10 kW, the electricity use is based on operating at: • 25% load for 25% of the UPS life (3.75 years) • 50% load for 50% of the UPS life (7.5 years) • 75% load for 25% of the UPS life (3.75 years) • 100% load at 0% of the UPS life (0 years) Product specific rules (PSR) for 3-phase UPS Reference Service Life (RSL) of a UPS Typical load profile of a UPS Life is On | Schneider Electric 3. Energy efficiency calculation The percent load and operating mode are important because they determine the UPS's efficiency at a specific load percentage. If a UPS has two operating modes, it will have two different efficiency values that characterize each mode. However, according to UPS PSR section 3.5.5.3, the electricity use calculation must be based on the UPS's operating mode with the worst case weighted efficiency; which in most cases is double conversion. The weighted efficiency for a 3-phase UPS (>10 kW) is calculated according to the formula: Weighted efficiency = 25% x Eff25% + 50% x Eff50% + 25% x Eff75% + 0% x Eff100% Product specific rules (PSR) for 3-phase UPS (continued) Efficiency figures at different load percentages for two operating modes (example: Galaxy VX 1250 kW) Weighted efficiency in double conversion = 25% x 95.6% + 50% X 96% + 25% x 95.7% + 0% x 95.2% = 95.8% Weighted efficiency in eConversion = 25% x 97.9% + 50% X 98.8% + 25% x 98.9% + 0% x 99% = 98.6% Life is On | Schneider Electric Because a UPS operates continuously over its lifetime, the largest contribution to its carbon emissions comes from the "use" stage. While there are significant differences among UPS models in terms of efficiency and the associated electrical losses, electricity consumption is by far the largest contributor of CO_2 e life cycle emissions. Here is an example of how each stage of the lifecycle contributes to the CO_2 e emissions of a 3-phase UPS taken from the Galaxy VX PEP. The use stage emissions represent about 93% of the UPS's carbon footprint. Carbon profile of a typical 3-phase UPS Manufacturing 6.2% Distribution 0.1% Installation 0.0% Use 93.3% End of life 0.4% Galaxy VX UPS 1250 - CO_2e emissions per life stage Manufacturing Distribution Installation Use End of life Use 93.3% Breakdown of total carbon footprint for a 3-phase UPS (example: Galaxy VX). Life is On | Schneider Electric UPS carbon footprint comparisons Life is On | Schneider Electric • A sustainability comparison makes sense only after developing a list of UPS models that meet your functional requirements. • In the case of a UPS, requirements may include kW capacity, physical footprint, efficiency, modularity, etc. Once you have a list of UPSs, then you can quantitatively compare their environmental characteristics. • The most effective way to do this is to compare their PEPs. • A comprehensive UPS carbon footprint comparison should consider all five of its life cycle stages. This section first explains common errors to avoid when comparing UPSs and then provides step by step guidance on comparing each of the five life cycle stages. • We use two UPSs to demonstrate the comparison. A key theme in this section is the concept of comparing "apples to apples." UPS carbon footprint comparisons Common errors to avoid when comparing products While the ISO standards provide the basis for LCAs and PEPs, they don't eliminate vendor mistakes or ensure valid comparisons. Therefore, end users must be vigilant when comparing PEPs for two or more UPSs, especially if they're from different vendors. This section covers the major errors people make when comparing the carbon footprint of two or more UPS. Life is On | Schneider Electric An emission factor is the ratio of greenhouse gas emitted for every kWh of electricity a utility generates. The emission factor is multiplied by the energy (kWh) the UPS uses in its lifetime to arrive at the use stage emissions from electrical losses. Because a UPS operates continuously over its lifetime, the largest contribution to its carbon emissions comes from the use stage. Even a small difference in emission factors has a major impact on a comparison. This is why you can't compare UPSs with different grid emission factors. An example of this frequent error is illustrated here. As shown in the table below, it's quite possible for a PEP of an inefficient UPS (e.g., UPS X at 94%) to show lower total emissions than a more efficient UPS (e.g., Galaxy VX at 95.8%) with an (erroneously calculated) 980,000 kg CO_2 e vs. 2,000,000 kg CO_2 e. In reality, only the second and the third line can be used for an apples-to-apples comparison, which shows that UPS X emissions are much higher than Galaxy VX. How different grid emission factors impact CO_2 e emissions declaration. Example: 1250kW UPS Efficiency % Grid Emissions Factor (kgCO_2/kWH) Grid geography CO_2 emissions declared in PeP (Use phase) in kgCO_2 UPS X 94% 0,2 FR 980 000 94% 0,41 EU-27 2 000 000 Galaxy VX 95,8% 0,41 EU-27 1 400 000 2 22kW UPS Comparing "use stage" carbon emissions based on different utility grid emission factorsError #1 When the emission factors are set equal (0.41 kg CO_2 e/kWh), the total CO_2 e footprint for the low-efficiency UPS is 1.4 times higher than the high-efficiency UPS. This example was calculated assuming an overall emission factor for the 27 European countries (0.41 kg CO_2 e/kWh) compared to that of France (0.2 kg CO_2 e/kWh) 6 . 6 This is an older (and higher) value than today's EU-27 and France values. The program operator, P.E.P. Association, tries to keep this value consistent over the years to avoid publishing PEP documents based on different emission factors. Life is On | Schneider Electric Example of CO_2 footprint comparison between UPS with different emission factors. Because PEPs use codes that can be difficult to understand, an easier way to assess the use stage emissions between two or more UPSs is to compare their efficiencies with the same grid emission factor. The 3-phase UPS Efficiency Comparison Calculator simplifies this task. 0 500,000 1,000,000 1,500,000 2,000,000 2,500,000 Manufacturing Distribution Installation Use End of life UPS CO_2e footprint UPS X - 94% eff using French EF (0.2 kg CO_2e/kWh UPS X - 94% eff using European EF (0.4 kg CO_2e/kWh GVX - 96% eff using European EF (0.4 kg CO_2e/kWh Incorrect comparison Correct comparison since both UPS use the same emission factor (EF) 2 2 2 Common errors to avoid when comparing products Life is On | Schneider Electric If a UPS has two operating modes, it will have two efficiency curves characterizing each mode. An example of this is illustrated using the Three Phase UPS Efficiency Comparison Calculator. Example of UPS efficiency curves for two different operating modes. • UPS with two operating modes will have two efficiency curves • Generally cannot compare values from different operating modes • If operator uses high-efficiency for one UPS but double conversion with another, values cannot be compared Comparing "use stage" carbon emissions with different operating modesError #2 Life is On | Schneider Electric Common errors to avoid when comparing products Declaring a winning attribute that is within the margin of errorError #7 Granting recycling credit without evidence of recycling programError #6 Assuming a PEP includes expected componentsError #5 Comparing UPS PEPs with different PSR and PCR versionsError #4 Comparing UPSs with different capacitiesError #3 Life is On | Schneider Electric Calculate the weighted UPS efficiency for the operating mode that will actually be used (e.g., double conversion or high-efficiency mode). The typical operating mode is double conversion. Do this for each UPS you're comparing using the formula provided below: This step requires: • The total energy consumption (kWh) – sum of all reference test loads from Step 2 • The grid emission factor (kg CO_2 e/kWh) – Ideally, the emission factor is the same as that of the electric grid supplying the UPS. This final step sums the emissions from all five life cycle stages (i.e., manufacturing, distribution, installation, use, and end of life) using the UPS PEP document. If the UPSs have different rated capacities, then you should compare the total carbon footprint using the 'K- factor' described above, or use the data from the nearest UPS rating provided in the PEP. This will allow you to see which UPS has the lowest total carbon footprint. This step requires the following for each UPS you're comparing: • The efficiencies from Step 1 • The grid emission factor (kg CO_2 e/kWh) – Ideally, the emission factor is the same as that of the electric grid supplying the UPS. • The rated capacity of the UPS (kW) • The UPS reference service life (RSL) (15 years) Step 1: Calculate the weighted efficiency. Step 3: Calculate UPS electricity CO_2 emissions. Step 4: Add CO_2 emissions from the other life stages. Step 2: Calculate UPS electricity consumption. Four steps for accurate UPS comparisons This section describes the steps required to accurately compare two or more UPSs. UPS life cycle electricity emissions (kg CO_2 e) Weighted efficiency Total energy consumption kWh Emission factor (kg CO_2 e/kWh) = = x 25% x Eff25% + 50% x Eff50% + 25% x Eff75% + 0% x Eff100% Life is On | Schneider Electric UPS carbon calculation tool This section describes the excel worksheet that facilitates UPS carbon footprint comparisons using the four steps described in the previous section. We describe each input that the worksheet uses to calculate the total life cycle carbon footprint for the UPS models you're comparing. All input cells are highlighted in yellow. Main input cells: UPS carbon footprint comparison tool In Step 1, the set of inputs describe the efficiency of the UPSs you're comparing. The UPS model and operating mode inputs are used only to label the efficiency data. The efficiency data should have at least one decimal of precision. Note, you must choose the operating mode that will actually be used at the site (typically double conversion). With the data provided by the Three Phase UPS Efficiency Comparison Calculator, you can enter the efficiencies in the yellow cells for most Schneider Electric UPSs. Table used to calculate weighted UPS efficiency: In Step 2 & 3, with the data entered thus far, the tool calculates the electricity consumption (kWh) and electricity-based emissions (kg CO_2 e) in the green rows. Table used to calculate the electricity consumption (kWh) and electricity- based emissions (kg CO_2 e): Per Step 4, the last part of the worksheet sums the emissions from the remaining life cycle stages (i.e., manufacturing, distribution, installation, and end of life) using the values in the UPS PEP document. The worksheet also calculates the emissions per unit kW of rated UPS capacity in case the UPSs have different rated capacities. Table used to calculate the total UPS life cycle carbon emissions (kg CO_2 e): Life is On | Schneider Electric Conclusion Life is On | Schneider Electric As more companies and consumers seek to reduce their environmental footprint, vendors are responding with claims of environmentally sustainable UPSs. Assessing the environmental sustainability of a UPS is complex and claims are difficult to ascertain without knowing the underlying assumptions and standards upon which they are made. By understanding the calculations behind the sustainability claims of the UPS you are considering, you can confidently choose a UPS that is better for your operations and the planet. This e-guide defined and covered five life cycle stages that encompass a UPS's environmental sustainability performance. We provided explanations for how to calculate the electricity-based UPS emissions. Finally, we offered guidance for how to accurately assess the sustainability of similar UPSs and a tool to help with UPS comparisons. Conclusion © 2024 Schneider Electric. All Rights Reserved. Schneider Electric, APC, EcoStruxure, and Smart-UPS are trademarks and the property of Schneider Electric SE, its subsidiaries and affiliated companies. All other trademarks are the property of their respective owners. 998-23218491_GMA To learn more about addressing your UPS's environmental sustainability, visit: se.com Schneider Electric 35 rue Joseph Monier 92500 Rueil-Malmaison, France Tel : +33 (0)1 41 29 70 00 General 05/2024 EcoStruxure™ Power for EV Battery Manufacturing Plants Utilizing a Digital Twin for Electrical Distribution to Drive Efficient Facilities Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Purpose of the Document Target Audience This document is intended to address End User Engineering, Operations and Maintenance, Consultants, EPCs (Engineering, Procurement, and Construction) and Service teams and other qualified personnel. Objective To understand the challenges of designing and operating an EV battery manufacturing plant with an efficient and sustainable electrical distribution strategy. Table of Contents Overview of capabilities Previous Next Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Table of Contents SECTION 1: Introduction to the Electrical Vehicle Battery Manufacturing Plants Introduces the context and the challenges of EV battery manufacturing plants. SECTION 2: How Schneider Electric Can Support Electrical Vehicle Battery Manufacturing Plants Describes the solutions that Schneider Electric and, more specifically EcoStruxure Power provides for EV battery manufacturing plants, with typical electrical and digital architecture. BIBLIOGRAPHY Contains useful documents to find out more about capabilities. Provides details about Green Premium. SECTION 3: Digital Solutions and Services Gives information about EcoStruxure Power capabilities for EV battery Manufacturing plants, sorted by value proposition: • Transverse Lifecycle Capabilities • Capabilities to Improve Time To Market • Capabilities to Improve Your Process • Capabilities to Improve Quality • Capabilities to Grow Sustainability Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General WHY READ THIS SECTION? SECTION 1 SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY EV Battery Market EV Battery Manufacturing Plant Challenges The objective of this section is to: • Introduce the growth, trends and challenges of the EV battery market • Present the 4 pillars to meet the EV battery manufacturing plant challenges. Introduction to the Electrical Vehicle Battery Manufacturing Industry Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY SECTION 1 – Introduction to the EV Battery Manufacturing Industry EV Battery Market EV Battery Manufacturing Plant Challenges EV Battery Market An industry driven by the electrical vehicle market 8 EV models Launched by Nissan by the end of 2023. Goal is to be on pace to sell 1M hybrid or electric vehicles per year globally. 15-25% sales of hybrid & EV For BMW by 2025. 20 EV models Launched by Audi by the end of 2025. 27 B$ investment By General Motors in EV infrastructure through 2025 with the aim of releasing 30 EV vehicles onto the market within the same timeframe 1 M hybrid & electrical vehicles On the road pledged by Volvo by end of 2025. Expectation of 50% of global sales from EVs. 10 EV models Introduced by Mercedes by the end of 2023. Ban of diesel- and gas-powered cars In the UK expected to go into effect by 2030. Sources https://www.caranddriver.com/news/g35562831/ev-plans-automakers-timeline/ Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY SECTION 1 – Introduction to the EV Battery Manufacturing Industry EV Battery Market EV Battery Manufacturing Plant Challenges EV Battery Market The market trends: a changing landscape Significant investment in Greenfield and expansions A growing focus on efficiency and sustainability High demand for energy and power to meet battery production capacity Cybersecurity Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY SECTION 1 – Introduction to the EV Battery Manufacturing Industry EV Battery Market EV Battery Manufacturing Plant Challenges How can we minimize downtime to increase yield rates and improve production quality? How can we be best-in- class for CO_2 emissions per kWh? How to improve the overall energy efficiency of the plant and process? How can we accelerate the design & build of new EV battery plants? EV Battery Manufacturing Plant Challenges Four pillars to drive efficiency, reliability and sustainability KPIs The strong growth of the EV market leads to an increasing need for battery manufacturing plants. Creating or expanding EV battery manufacturing plants is not without its challenges. Four pillars must be addressed: Grow Sustainability Improve Quality Improve Your Process Improve Time to Market How can we reduce the cost of finished battery cells? Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General WHY READ THIS SECTION? SECTION 2 SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Solutions to Address the Four Pillars Schneider Electric Value Propositions Example of Electrical and Digital Architecture The objective of this section is to: • Present the solutions to address the four pillars to meet the EV battery manufacturing plant challenges • Explain how Schneider Electric EcoStruxure™ Power can support this industry • Give an example of electrical and digital architectures. How Schneider Electric Can Support Electrical Vehicle Battery Manufacturing Plants Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General Schneider Electric Value Propositions Example of Electrical and Digital Architecture Solutions to Address the Four Pillars SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Solutions to Address the Four Pillars of EV Battery Manufacturing Plants The four pillars can be addressed by the following solutions: Increase Production Efficiency Reduce Production Hazards Track Sustainability KPIs Use Standardized Architectures Use standardized electrical distribution and IT infrastructures in order to speed up the "design, build and commission" phase of new plants. Digitize and modernize your operations and turn data into useful business intelligence to empower your workforce, understand the profitability of your production assets and make smart business decisions for your entire ecosystem. Reduce downtimes and manage end-to-end quality to reduce production scrap. Utilize control tower and IoT platforms to collect analytics on processes, settings and maintenance. Monitor sustainability criteria to accelerate environmental transition and be compliant with sustainability standards and customer expectations. Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Example of Electrical and Digital Architecture Solutions to Address the Four Pillars Schneider Electric Value Propositions SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Schneider Electric Value Propositions At company level Through its entire organization, Schneider Electric has developed value propositions to address the four pillars for the different parts of EV battery manufacturing plants: Infrastructure / Facility Manufacturing Process Manufacturing Machine Design and Modeling Digital Automation & IOT Framework EcoStruxure Machine Architecture Energy Efficiency Process Efficiency Machine Performance & Flexibility Power Availability Predictive Quality Machine Tracking & Monitoring Green House Gas and Energy Compliance Energy Optimization Sustainable Sourcing Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Transverse Lifecycle Capabilities (Cybersecurity, Green Premium, Digital Twin) Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Example of Electrical and Digital Architecture Solutions to Address the Four Pillars Schneider Electric Value Propositions SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Schneider Electric Value Propositions At EcoStruxure Power level This guide focuses more specifically on value propositions provided by EcoStruxure Power: Manufacturing Process Manufacturing Machine Digital Automation & IOT Framework EcoStruxure Machine Architecture Process Efficiency Machine Performance & Flexibility Predictive Quality Machine Tracking & Monitoring Energy Optimization Sustainable Sourcing Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Transverse Lifecycle Capabilities (Cybersecurity, Green Premium, Electrical Digital Twin) Infrastructure / Facility Design and Modeling Energy Efficiency Power Availability Green House Gas and Energy Compliance Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Example of Electrical and Digital Architecture Solutions to Address the Four Pillars Schneider Electric Value Propositions SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Schneider Electric Value Propositions At EcoStruxure Power level EcoStruxure Power helps deliver an end-to-end digital solution for efficient, reliable and sustainable EV Battery Plants. From electrode production to cell finishing, From electrical design to operations and maintenance, Our collaborative environments, enhanced by the Electrical Distribution Digital Twin of your Plant, enable high productivity operations. Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Solutions to Address the Four Pillars Schneider Electric Value Propositions Example of Electrical and Digital Architecture SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Example of Electrical and Digital Architecture Typical EV battery manufacturing plant Energy is key, whether for processes or for utilities: specific attention must be given to the design of the electrical architecture and associated digital architecture which will enable digital solutions and services. EV battery manufacturing plant PROCESS Energy consumption 60 % UTILITY Energy consumption 40 % Cell assembly Utilities – Clean and dry room Ageing/Formation Utilities Infrastructure 3%Mixing Coating and drying Vacuum drying Calendering Slitting 23 % 2% 2% 2% 2% 26 % 37 % 3% Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Solutions to Address the Four Pillars Schneider Electric Value Propositions Example of Electrical and Digital Architecture SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Example of Electrical and Digital Architecture Typical electrical architecture for an EV battery manufacturing plant Example of Electrical Architecture General Example of Electrical Architecture Expensive Process = Power Availability High Energy demand = Efficient Energy Management ELECTRODE PRODUCTION • Mixing • Coating & Drying • Calendering • Slitting • Vacuum Drying CELL ASSEMBLY • Electrode shaping • Stacking • Electric contacting • Case insertion • Case closure CELL FINISHING • Electrolyte filling Pre-charging • Filling hole closure • Ageing & formation INFRASTRUCTURE • Emergency Loads • IT and Control Room • Lightings and other UTILITIES • Dry Room MV Chillers and Dryers • Clean Room MV Chillers • Cooling Water • Waste Treatment • Inert gas (N2) PROCESS UTILITY 60 % 40 % Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Solutions to Address the Four Pillars Schneider Electric Value Propositions Example of Electrical and Digital Architecture SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Example of Electrical and Digital Architectures Suggested digital architecture (high-level view) for an EV battery manufacturing plant Example of Digital Architecture (High-Level View) General Example of Digital Architecture (High-Level View) Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Solutions to Address the Four Pillars Schneider Electric Value Propositions Example of Electrical and Digital Architecture SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Example of Electrical and Digital Architectures Corresponding detailed digital architecture for an EV battery manufacturing plant Example of Digital Architecture (Detailed View) General Example Digital Architecture (Detailed View) Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General WHY READ THIS SECTION? SECTION 3 SECTION 3 – Digital Solutions and Services Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY This section gives information about EcoStruxure Power capabilities for EV battery manufacturing plants aligned to the industry challenges. Digital Solutions & Services Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Introduction SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Introduction EcoStruxure Power provides capabilities to support the challenges of EV battery manufacturing plant throughout the plant lifecycle: These capabilities provide standardized designs and digital architectures, and enable easy simulation, to reduce cost of design and ownership. These capabilities use digitization to provide intelligent information to the workforce, allowing them to make smart decisions that reduce operating costs and increase efficiency. These capabilities use digitization to reduce unplanned downtime, increase reliability, and thus reduce production waste. These capabilities help track energy consumption and carbon emissions to meet sustainability requirements. Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities Digital Solutions that support your project from the Design, Build, Commission to Operate & Maintain phases. Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Overview of Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Asset performance Power quality monitoring and compliance Continuous thermal monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry Capabilities to Grow Sustainability Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Asset performance Power quality monitoring and compliance Continuous thermal monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry Capabilities to Grow Sustainability Electrical Digital Twin Maintain a Digital Twin of your electrical distribution Benefits • Intelligent user-interface for all levels of AC and DC networks • Enables users, from the design to operate phases, to model, simulate, analyze and validate electrical power systems to predict their electrical network behavior • Takes the day-to-day system modeling and design tasks to a new level of speed, accuracy and ease Electrical Digital Twin Transverse Lifecycle Capabilities Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry Capabilities to Grow Sustainability Green Premium Manage sustainability from design to end of life Benefits • Green Premium* products provide detailed information on their regulatory compliance, material content, environmental impact, and circularity attributes. Transverse Lifecycle Capabilities Compliance and transparency (compliance certificates, circularity profiles, environmental footprint, etc.)1 Circular performance Durability, upgradeability, re-manufacture, recycled content, recyclability Well-being performance E.g. free of PVC, mercury, silicone, SVHC, lead, toxic heavy metal and compliant with California Prop 65 4 Resource performance Optimized energy performance Lower carbon emissions 2 3 * The Green Premium label was created to provide Schneider Electric's customers with more sustainable products and to be transparent with environmental information. Supporting your efforts for a LEED certified building Helping you achieve Living Building Challenge certification Green Premium Value Proposition Learn more about: • Green Premium Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry Capabilities to Grow Sustainability Cybersecurity Help secure the digital power distribution system Benefits • Provides a selection of cybersecurity certified products • Provides certified system architectures and solutions • Delivers lifecycle services Transverse Lifecycle Capabilities Learn more about: • Cybersecurity Certified products developed according to IEC 62443 functional requirements with Secure Development Lifecycle processes. Consulting services from design, implementation, operations and maintenance to tailor your security solutions to your strategy and budget. Lifecycle services Certified secure system architecture according to IEC 62443-3-3 with documented processes and solutions for a secure system. Cybersecurity system configuration software for consistent security policy deployment. Certified products Certified systems & solutions Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Asset performance Power quality monitoring and compliance Continuous thermal monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction Simulate before Operate Arc flash protection + + + + + + + + + Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability AC and DC Electrical Network Bus Design and Simulation Optimize bus design allocation and simulation Primary Department • Design • Construction Benefits • Single solution/environment - Unified AC & DC solution from HV to LV - One unique platform and one database • Efficient profile management - User-defined loading and generation profiles - External data profile based on field measurements • Scalability - Load growth study for future planning • Event simulations within the calculation period Capabilities to Improve Time to Market ETAP Electrical Network Model Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Electrical Network Short Circuit Simulation Design and simulate unbalanced short circuits Primary Department • Design • Construction Benefits • Expedite design studies with a wide range of calculation scenarios, including advanced fault analysis - IEC & ANSI duty calculation for balanced and unbalanced faults - Simultaneous fault at selected nodes - Inclusive 3-Phase and 1-Phase fault analysis - Pre-Fault system loading consideration Electrical Network Short Circuit Simulation in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Network Load Flow and Voltage Drop Simulation Perform power flow analysis and voltage drop calculations Primary Department • Design • Construction Benefits • Simulation of bus voltages, branch power factors, currents, system losses, power generation versus loading • Use of ETAP Electrical Digital Twin model with powerful calculation engines and user-friendly interface • Simulation using multiple loading and generation conditions Network Load Flow and Voltage Drop Simulation in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Device Coordination and Selectivity Automatically detect and evaluate the system protection and coordination/selectivity Primary Department • Design • Construction Benefits • Verified and validated libraries • Graphically adjustable device settings • Detailed device settings reporting • Continuous synchronization with one-line and integrated equipment database Device Coordination and Selectivity in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Arc Fault Protection and Coordination Perform sequence of operation for arc fault and bolted fault Primary Department • Design • Construction Benefits • Evaluate, verify, and confirm the operation and selectivity of the protective devices for various types of faults for any location directly from the single-line diagram • Animation displayed on the single-line diagram • 3-phase / 1-phase sequence of operation Arc Fault Protection and Coordination in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Power Quality Simulation and Modeling Evaluate and validate distortion due to harmonics Primary Department • Design • Construction Benefits • Simulate harmonic current and voltage sources: - To identify potential harmonic problems (report of harmonic voltage and current distortion limit violations) - To identify the need for a harmonics filter • Simulate and analyze the size of the harmonics filter your system will need to optimize performance and reduce nuisance trips Capabilities to Improve Time to Market Power Quality Simulation and Modeling in ETAP Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Renewable and Microgrid Energy Storage Sizing Simulation Design and optimize the microgrid system Primary Department • Design • Construction Benefits • Build renewable energy models combined with full spectrum power system analysis calculations for: - Accurate simulation - Predictive analysis - Equipment sizing - Field verification of wind, solar farms and other DERs • Enable designers and engineers to conceptualize the collector systems, determine wind penetration and perform grid interconnection studies Microgrid Energy Storage Sizing Simulation in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Your Process SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Quality Capabilities to Grow Sustainability Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Asset performance Power quality monitoring and compliance Continuous thermal monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction Arc flash protection Simulate before Operate + + + + + + + + + Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Your Process SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Quality Capabilities to Grow Sustainability Operator Training Simulation Train new employees and build confidence on new systems Primary Department • Facility Operations & Maintenance Benefits • Practice operation within a simulated but highly realistic environment to enhance safety and operational efficiency • Track and review trainee actions to analyze and challenge them + Capabilities to Improve Your Process Learn more about: • Operator Training Simulation (IEC / NEMA) Principle of Operator Training Simulation Application Operator Training Simulation Reference Architecture General Operator Training Simulation Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Your Process SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Quality Capabilities to Grow Sustainability Energy Monitoring and Usage Analysis Determine where to focus energy conservation initiatives Primary Department • Facility Operations & Maintenance Benefits • Bring awareness to utility consumption - Turn data into easy-to-interpret graphical dashboards and reports to raise awareness amongst key stakeholders • Identify "quick-win" opportunities for energy savings - By comparing and visualizing energy usage and cost for different utilities over different time periods - By identifying and prioritizing which areas lend themselves to a high energy-saving return on investment Capabilities to Improve Your Process Energy Usage Analysis Dashboards in EcoStruxure Power Operation Learn more about: • Energy Monitoring (IEC / NEMA) Energy Monitoring and Usage Analysis Reference Architecture General Energy Monitoring and Usage Analysis Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Your Process SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Quality Capabilities to Grow Sustainability Energy Performance, Modeling and Verification Analyze the energy performance of a plant against a model baseline Primary Department • Facility Operations & Maintenance Benefits • Provide energy usage information based on equipment and processes • Compare model versus actual consumption • Compare pre-retrofit versus post-retrofit energy consumption to track improved performance and savings as a result of energy conservation initiatives Capabilities to Improve Your Process Energy Performance, Modeling and Verification Output in EcoStruxure Power Operation Learn more about: • Energy Performance (IEC / NEMA) • Energy Modeling and verification (IEC / NEMA) Energy Performance, Modeling and Verification Reference Architecture General Energy Performance Modeling and Verification Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Your Process SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Quality Capabilities to Grow Sustainability Capacity Management Monitor the capacity of electrical distribution Primary Department • Facility Operations & Maintenance Benefits • Monitor electrical network capacity • Track and review capacity efficiency • Minimize downtime by tracking the capacity of transformers, circuit breakers, UPSs, generators, etc. Capabilities to Improve Your Process Breaker Capacity Single-line Diagram in EcoStruxure Power Operation Learn more about: • Capacity Management (IEC / NEMA) Capacity Management Reference Architecture General Capacity Management Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities Asset performance Power quality monitoring and compliance Continuous thermal monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Predictive Simulation Help employees make better decisions Primary Department • Facility Engineering • Design Engineering Benefits • Reduce safety risks by practicing emergencies and high-risk situations • Enhance operational efficiency by running "what-if" scenarios • Provide faster analysis response to incidents Capabilities to Improve Quality + Principle of Predictive Simulation Application Predictive Simulation Reference Architecture General Predictive Simulation Application Digital Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Simulate Before Operate Empower operators with predictive outcomes Primary Department • Facility Operations & Maintenance Benefits • Provide operators with a list of potential side effects, prior to executing a command • Empower employees to feel more confident when operating their facilities by providing real time guidance • Reduce human error that could lead to outages or safety concerns Capabilities to Improve Quality Learn more about: • Simulate Before Operate (IEC / NEMA) Principle of Simulate before Operate Application Simulate Before Operate Reference Architecture General Simulate Before Operate Application Digital Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Electrical Distribution Monitoring and Alarming Monitor and control electrical network Primary Department • Facility Operations & Maintenance Benefits • Show real-time status of the power distribution • Customized single-line diagram • 24/7 power monitoring and alarm notification Capabilities to Improve Quality Electrical Distribution Monitoring and Alarming Single-line Diagram in EcoStruxure Power Operation Learn more about: • Electrical distribution monitoring and alarming (IEC / NEMA) • Power Source and Load Control (IEC / NEMA) Electrical Distribution Monitoring and Alarming Reference Architecture General Electrical Distribution Monitoring and Alarming Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Power Event Analysis Analyze the root causes of electrical events Primary Department • Facility Operations & Maintenance Benefits • Automatically classifies and describes any electrical events • Uses system intelligence to determine root cause and location of events • Shows context and sequence of events using the timeline analysis interface Event and Alarm Status view in EcoStruxure Power Operation Event and Alarm Status Timeline in EcoStruxure Power Operation Capabilities to Improve Quality Learn more about: • Power Event Analysis (IEC / NEMA) Power Event Analysis Reference Architecture General Power Event Analysis Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Asset Performance Benefit from a strategic maintenance approach Primary Department • Facility Operations & Maintenance Benefits • Move from reactive or preventive to condition-based (predictive) maintenance strategies for critical assets like circuit breakers, gensets, transformers, etc. • Provide event details and notification to the operator if a protection setting has been changed • Receive notifications and diagnostics reports from expert service engineers with recommendations to optimize maintenance by asset or site Capabilities to Improve Quality Aging Diagram for Circuit Breakers in EcoStruxure Power Operation Gigafactory Learn more about: • Asset Performance (IEC / NEMA) Asset Performance Reference Architecture General Asset Performance Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to

Improve Your Process Capabilities to Grow Sustainability Power Quality Monitoring and Compliance Gain insights to improve power quality and comply with standards Primary Department • Facility Operations & Maintenance Benefits • Bring awareness of power quality • Enhance operational efficiency by making sure clean power is fed to sensitive process equipment • Help protect sensitive equipment by tracking power quality problems before they arise Capabilities to Improve Quality Power Quality and Compliance Dashboards in EcoStruxure Power Operation Power Quality and Compliance Report in EcoStruxure Power Operation Learn more about: • Power Quality Monitoring and Compliance (IEC / NEMA) Power Quality Monitoring and Compliance Reference Architecture General Power Quality Monitoring and Compliance Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Power Quality and Power Factor Correction Help protect sensitive equipment from power quality issues Primary Department • Facility Operations & Maintenance Benefits • Monitor sensitive process lines and busbars • Provide clean power to sensitive process equipment • Track Power Quality problems to help avoid downtime • Reduce financial impact of power factor on energy bill Capabilities to Improve Quality Galaxy VM Power Quality Information in EcoStruxure Power Operation Before and After Power Quality and Power Factor Correction ImplementationLearn more about: • Power Quality Correction (IEC / NEMA) • Power Factor Correction (IEC / NEMA) Power Quality and Power Factor Correction Reference Architecture General Power Quality and Power Factor Correction Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Continuous Thermal Monitoring Help prevent electrical fires and help protect equipment Primary Department • Facility Operations & Maintenance Benefits • Bring early detection of temperature abnormalities • Help reduce the risk of equipment and electrical room damage and improve service continuity • Enable cost effective maintenance Continuous Thermal Monitoring in the Single-line Diagram of EcoStruxure Power Operation Continuous Thermal Monitoring Reference Architecture Capabilities to Improve Quality Learn more about: • Continuous Thermal monitoring (IEC / NEMA) General Continuous Thermal Monitoring Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Arc Flash Protection Help protect employees and equipment Primary Department • Facility Operations & Maintenance Benefits • Help prevent loss of life and reduce the risk of equipment and electrical room damage • Improve maintenance team awareness to help troubleshoot and identify the root cause of arc flash events Capabilities to Improve Quality Learn more about: • Arc Flash Protection (IEC / NEMA) Arc Flash in a Switchboard Arc Flash Alert and Location in EcoStruxure Power Operation Arc Flash Protection Reference Architecture General Arc Flash Protection Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Asset performance Power quality monitoring and compliance Continuous thermal monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Carbon Neutrality Consulting Services Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Get support from our consulting services to define your strategy for achieving carbon neutrality Track and reduce carbon emissions to demonstrate the carbon neutrality of the company Capabilities to Grow Sustainability + Services Carbon neutrality Reduce Carbon Emissions Produce Renewable Energy Purchase Renewables/Offsets Energy Efficiency • Sustainable building design & operations – HVAC Efficiency – Lighting Efficiency – Operational Efficiency Behind-the-Meter Renewables • Solar Panels / Heating • Wind • Geothermal Purchase Renewables • Renewable Power Purchasing Agreements (PPA) • Renewable Energy Certificates (REC) • Biofuels Supporting Technologies • Microgrid with Smart Management • Battery Storage • Fuel Cells Purchase Offsets • Carbon Credits – Carbon Capture – Tree Planting 1 2 3 Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Energy Efficiency Compliance Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Report and show facility compliance to local sustainability requirements - To benefit from tax credits - To gain credibility to participate in new projects Comply with standards related to energy management systems Capabilities to Grow Sustainability EcoStruxure Power Operation Energy Star Compliance Dashboard EcoStruxure Resource Advisor Dashboard in EcoStruxure Power Operation Sustainable Organizations and Standards Learn more about: • Energy Efficiency Compliance (IEC / NEMA) Energy Efficiency Compliance Reference Architecture General Energy Efficiency Compliance Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Greenhouse Gas Reporting Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Track and report carbon emissions and waste (e.g., water) in one single place • Provide period-over-period usage comparison to detect a drift Track and report carbon emissions Greenhouse Gas Reporting and Dashboard Examples in EcoStruxure Power Operation Capabilities to Grow Sustainability Greenhouse Gas Reporting Reference Architecture Learn more about: • Greenhouse Gas Reporting (IEC / NEMA) General Greenhouse Gas Reporting Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Reference Documents Legal Information BIBLIOGRAPHY Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General BIBLIOGRAPHY Reference Documents SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Legal Information Reference Documents Design Guide IEC EcoStruxure Power Design Guide Ref: ESXP2G001EN 02/2024 Digital Applications for Large Buildings and Critical Facilities The Digital Applications Design Guide provides comprehensive details on the building blocks of EcoStruxure Power: the IoT applications are driven by a software layer to control the traditional electrical distribution infrastructure. Developed to help engineering consultants and designers, this guide is an invaluable resource for specifying, designing and prescribing EcoStruxure Power architectures capable of performing one or more of the business-driven applications described within. NEMA EcoStruxure Power Design Guide Ref: 0100DB1802 01/2024 https://www.se.com/ww/en/downl oad/document/ESXP2G001EN/ https://www.se.com/us/en/download/ document/0100DB1802/ Web version PDF version Web version https://go.schneider- electric.com/WW_202004_Digital- Applications-for-Large-Buildings-and- Critical-Facilities_EA-LP.html PDF version https://go.schneider- electric.com/WW_202004_Digital- Applications-Design-Guide_EA-LP.html Landing page: https://www.se.com/ww/en/work/campaign/innovation/power-digital-applications-design-guide.jsp Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General Legal Information SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Reference Documents Legal Information The information provided in this document contains general descriptions, technical characteristics and/ or recommendations related to products/solutions. This document is not intended as a substitute for a detailed study or operational and site-specific development or schematic plan. It is not to be used for determining suitability or reliability of the products/solutions for specific user applications. It is the duty of any such user to perform or have any professional expert of its choice (integrator, specifier or the like) perform the appropriate and comprehensive risk analysis, evaluation and testing of the products/solutions with respect to the relevant specific application or use thereof. The Schneider Electric brand and any trademarks of Schneider Electric SE and its subsidiaries referred to in this document are the property of Schneider Electric SE or its subsidiaries. All other brands may be trademarks of their respective owner. This document and its content are protected under applicable copyright laws and provided for informative use only. No part of this document may be reproduced or transmitted in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise), for any purpose, without the prior written permission of Schneider Electric. Schneider Electric does not grant any right or license for commercial use of the document or its content, except for a non- exclusive and personal license to consult it on an "as is" basis. Schneider Electric reserves the right to make changes or updates with respect to or in the content of this document or the format thereof, at any time without notice. To the extent permitted by applicable law, no responsibility or liability is assumed by Schneider Electric and its subsidiaries for any errors or omissions in the informational content of this document, as well as any non-intended use or misuse of the content thereof. AccuSine™, Acti 9™, Altivar™, ASCO™, BlokSeT™, ComPacT™, EcoStruxure™, EnerLin'X™, ETAP™, EVlink™, EvoPacT™, Galaxy™, Harmony™, Iso-Gard™, Masterclad™, MasterPacT™, MicroLogic™, Modicon™, Okken™, PowerLink™, PowerLogic™, PowerPacT™, Power-Zone™, PremSeT™, PrismaSeT™, Schneider Electric™, SM AirSeT™, Square D™, SureSeT™, TeSys™, TransferPacT™, Trihal™,and Vigilohm™ are trademarks and the property of Schneider Electric SE, its subsidiaries, and affiliated companies. General 2024/05/28 ESXP2RG001EN Schneider Electric Industries SAS 35, rue Joseph Monier CS 30323 92506 Rueil Malmaison Cedex France www.se.com © 2024 Schneider Electric. All Rights Reserved. All trademarks are owned by Schneider Electric SE, its subsidiaries and affiliated companies. All other brands are trademarks of their respective owners Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Status Data 40002 0x0001 1 UPS Status 1 0 UPS operation mode - Battery BOOLEAN 1=UPS operation mode - Battery 1 Battery is below minimum acceptable runtime BOOLEAN 1=Battery is below minimum acceptable runtime 2 Bypass BOOLEAN 1=UPS is in Bypass 3 UPS operation mode - Battery Test BOOLEAN 1=UPS operation mode - Battery Test 4 Reserved BOOLEAN 5 High Efficiency Mode disable by system BOOLEAN 1=High Efficiency Mode (ECO, ECOnversion) disable by system 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Battery fault BOOLEAN 1=Battery fault 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Informational alarm present BOOLEAN 1=Informational alarm present 14 Warning alarm present BOOLEAN 1=Warning alarm present 15 Critical alarm present BOOLEAN 1=Critical alarm present 40003 0x0002 2 Alarm Register 1 0 Lost local network management interface - to - UPS communication BOOLEAN 1=Lost local network management interface - to - UPS communication 1 Display communication is lost BOOLEAN 1=Main Controller is unable to communicate with the display 2 Parallel communication incorrect on PBUS cable 1 BOOLEAN 1=Parallel communication incorrect on PBUS cable 1 3 Parallel communication incorrect on PBUS cable 2 BOOLEAN 1=Parallel communication incorrect on PBUS cable 2 4 MegaTie activation alarm BOOLEAN 1=MegaTie activation is present 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Communication cable termination fault BOOLEAN 1=Communication cable termination fault 13 General parallel system incorrect BOOLEAN 1=General parallel system incorrect 14 Lost parallel redundancy BOOLEAN 1=Lost parallel redundancy 15 Reserved BOOLEAN 40004 0x0003 3 Alarm Register 0 Reserved BOOLEAN 1 UPS operation mode - Requested Static Bypass BOOLEAN 1=UPS operation mode - Requested Static Bypass 2 UPS operation mode - Forced Static Bypass BOOLEAN 1=UPS operation mode - Forced Static Bypass Modbus Register Map:Galaxy VX (3:3 250kW-1500kW) Scale Notes: 1. 16-bit registers are transmitted MSB first (i.e. big-endian). 2. INT32 and UINT32 are most-significant word in n+0, least significant word in n+1 (i.e. big-endian). 3. Function codes 3 and 4 are supported 4. Modbus serial RTU and Modbus over TCP is supported. 5. Signed numbers are twos-compliment 6. Status bits are atomic within a single Modbus register. User should not look for consistency across multiple registers, only within a single register. 7. For ASCII strings less than the maximum length, the unused characters are filled with nulls. 8. Single-register reads of reserved or undefined registers will return an error. Block reads which begin with a valid register will not return an error but will return zeros for undefined registers. 9. Strings are two characters per register, first character in high-order byte, second character in low-order byte. Printable ASCII only. 10. Bit #0 is least significant bit. 11. Data Type column: "INT16"=signed 16-bit integer, "UINT16" = unsigned 16-bit integer, "INT32" = signed 32-bit integer, "UINT32" = unsigned 32-bit integer, "ENUM" is a UINT16 value which maps to a defined list of states, "ASCII" = the printable ASCII subset from 0x20 - 0x7E. BOOLEAN= a single bit, 0 or 1. 12. "Absolute Starting Register Address" = 0 (the column heading used in this table) is equivalent to "Register 40001" in Modicon terminology, which is address zero when transmitted over the wire. For detailed modbus configuration settings, please refer to the Display or AP9635 User's Guide. 990-5915E May/ 2024 Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 3 UPS operation mode - Maintenance Bypass BOOLEAN 1=UPS operation mode - Maintenance Bypass 4 Reserved BOOLEAN 5 UPS operation mode - Off BOOLEAN 1=UPS operation mode - Off 6 UPS operation mode - Initialize BOOLEAN 1=UPS operation mode - Initialize 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Input phase sequence incorrect BOOLEAN 1=Input phase sequence incorrect 12 Input frequency out of range BOOLEAN 1=Input frequency out of range 13 Input voltage out of range BOOLEAN 1=Input voltage is out of range 14 Selftest - Failed BOOLEAN 1=Self test has failed 15 Power cabinet mixed operation mode (Battery and Normal) BOOLEAN 1=Power Cabinet in mixed operation mode (Battery and Normal) 40005 0x0004 4 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Bypass frequency out of range BOOLEAN 1=Bypass frequency out of range 4 Bypass phase sequence incorrect BOOLEAN 1=Bypass phase sequence incorrect 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Overload on UPS BOOLEAN 1=Overload on UPS 9 Overload on Static bypass switch BOOLEAN 1=Overload on Static bypass switch 10 Ambient temperature out of range BOOLEAN 1=Ambient temperature out of range 11 EPO Switch Activated BOOLEAN 1=EPO Switch activated 12 Ground fault detected BOOLEAN 1=Ground fault detected 13 Reserved BOOLEAN 14 Bypass voltage out of range BOOLEAN 1=Bypass voltage is out of range 15 High Efficiency mode is disable due to bypass UTHD BOOLEAN 1=Bypass UTHD is out of range for High Efficiency Mode 40006 0x0005 5 Alarm Register 1 0 System locked in bypass operation BOOLEAN 1=System locked in bypass operation 1 Batteries are discharging BOOLEAN 1=Batteries are discharging 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Continuous Overload on UPS BOOLEAN 1=Overload on UPS present. Load below Continuous Overload Threshold. 5 Charge power is reduced BOOLEAN 1=Charge power is reduced 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Distributed Energy Reserved Mode activated BOOLEAN 1= Distributed Energy Reserved mode activated 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Battery condition is weak BOOLEAN 1=Battery condition is weak 13 Battery condition is poor BOOLEAN 1=Battery condition is poor 14 Reserved BOOLEAN 15 Battery capacity is below minimum acceptable level BOOLEAN 1=Battery capacity is below minimum acceptable level 40007 0x0006 6 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Power cabinet redundancy lost BOOLEAN 1=Power cabinet redundancy lost 40008 0x0007 7 Alarm Register 1 0 Reserved BOOLEAN 1 Bypass transfert inhibited by relay input activated BOOLEAN 1= transfert to bypass is inhibited by input relay activated 2 DC ground fault BOOLEAN 1= DC ground fault is present Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 3 Ambient temperature high BOOLEAN 1 = Ambient temperature is high 4 Overload on UPS due to high ambient temperature BOOLEAN 1 = Overload on UPS due to high ambient temperature 5 Output frequency out of range BOOLEAN 1=Output frequency out of range 6 Output voltage out of range BOOLEAN 1=Output voltage is out of range 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Overload on installation BOOLEAN 1=Overload on installation 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40009 0x0008 8 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 UOB Auxiliary wiring not correct BOOLEAN 1= UOB Aux wiring is not correct 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40010 0x0009 9 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Load bank breaker closed, parallel test mode enabled BOOLEAN 1=Load bank breaker closed, parallel test mode enabled 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Unit Unit Breaker (UIB) open BOOLEAN 1=Unit Unit Breaker (UIB) open 10 Unit Ouput Breaker (UOB) open BOOLEAN 1=Unit Ouput Breaker (UOB) open 11 Maintenance Bypass Breaker (MBB) closed BOOLEAN 1=Maintenance Bypass Breaker (MBB) closed 12 System Isolation Breaker (SIB) open BOOLEAN 1=System Isolation Breaker (SIB) open 13 Static Switch Input Breaker (SSIB) open BOOLEAN 1=Static Switch Input Breaker (SSIB) open 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40011 0x000A 10 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Static bypass switch inoperable BOOLEAN 1=Static bypass switch has a critical alarm that prevents it from operating 9 Static bypass switch warning BOOLEAN 1=Static bypass switch has an alarm with severity level warning 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40012 0x000B 11 RESERVED 2 40014 0x000D 13 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 3 Reserved BOOLEAN 4 Battery room ventilation inoperable BOOLEAN 1=Battery room ventilation inoperable 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 External battery monitoring alarm BOOLEAN 1=External battery monitoring alarm 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40015 0x000E 14 Alarm Register 1 BOOLEAN 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 High Battery Temperature Level BOOLEAN 1=Battery temperature above alarm setting 4 Low Battery Temperature Level BOOLEAN 1=Battery temperature below alarm setting 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Battery breaker BB1 open BOOLEAN 1=Battery breaker BB1 open 12 Battery breaker BB2 open BOOLEAN 1=Battery breaker BB2 open 13 Battery breaker BB3 open BOOLEAN 1=Battery breaker BB3 open 14 Battery breaker BB4 open BOOLEAN 1=Battery breaker BB4 open 15 Delayed transfer from Battery to Normal Operation BOOLEAN 1=The delayed transfer from Battery to Normal Operation is active. 40016 0x000F 15 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Breaker BF2 open BOOLEAN 1= breaker BF2 open 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Li-Ion AC Supply Breaker BMS:B1/BMS:B2 open BOOLEAN 1=Li-Ion AC Supply Breaker BMS:B1/BMS:B2 open 15 Reserved BOOLEAN 40017 0x0010 16 Alarm Register 1 0 UPS operation mode - Static bypass standby BOOLEAN 1=UPS operation mode - Static bypass standby 1 UPS operation mode - Inverter standby BOOLEAN 1=UPS operation mode - Inverter standby 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 General UPS settings incorrect BOOLEAN 1=General UPS settings incorrect 5 UPS configuration incorrect BOOLEAN 1=UPS general configuration is incorrect 6 Synchronization unavailable BOOLEAN 1=Synchronization unavailable - system is free running 7 Fan inoperable BOOLEAN 1=UPS has one or more inoperable fans. Fan redundancy is lost. 8 Inverter is Off due to a request by the user BOOLEAN 1= Inverter is Off due to a request by the user 9 Restricted air flow BOOLEAN 1=Restricted air flow 10 Surveillance detected a fault BOOLEAN 1=Surveillance detected a fault 11 Charger status BOOLEAN 1=Inoperable 12 Inverter status BOOLEAN 1=Inoperable 13 PFC status BOOLEAN 1=Inoperable 14 Battery status BOOLEAN 1=Inoperable 15 Reserved BOOLEAN 40018 0x0011 17 Alarm Register 1 0 Technical check recommended BOOLEAN 1=Technical check recommended 1 Start-up recommended BOOLEAN 1= Secure start-up recommended 2 Warranty expiring soon BOOLEAN 1=Warranty expiring soon 3 Reserved BOOLEAN Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 4 Air filter check recommened BOOLEAN 1=Air filter check recommened 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40019 0x0012 18 RESERVED 1 40020 0x0013 19 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Not enough UPSs ready to turn on inverter BOOLEAN 1=Not enough UPSs ready to turn on inverter 6 Parallel UPS 1 not present BOOLEAN 1=Parallel UPS 1 not present 7 Parallel UPS 2 not present BOOLEAN 1=Parallel UPS 2 not present 8 Parallel UPS 3 not present BOOLEAN 1=Parallel UPS 3 not present 9 Parallel UPS 4 not present BOOLEAN 1=Parallel UPS 4 not present 10 Parallel UPS 5 not present BOOLEAN 1=Parallel UPS 5 not present 11 Parallel mixed operation mode BOOLEAN 1=Parallel mixed operation mode 12 Firmware versions in parallel UPS units are not identical BOOLEAN 1=Firmware versions in parallel UPS units are not identical 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40021 0x0014 20 RESERVED 1 40022 0x0015 21 Alarm Register 1 0 System operation mode - Off BOOLEAN 1 = System operation mode - Off 1 System operation mode - Forced static bypass BOOLEAN 1 = System operation mode - Forced static bypass 2 System operation mode - Requested static bypass BOOLEAN 1 = System operation mode - Requested static bypass 3 System operation mode - Maintenance bypass BOOLEAN 1 = System operation mode - Maintenance bypass 4 System operation mode - Static Bypass Standby BOOLEAN 1 = System operation mode - Static Bypass Standby 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40023 0x0016 22 Alarm Register 1 0 Input missing phase BOOLEAN 1=Input is missing a phase 1 Bypass missing phase BOOLEAN 1=Bypass input is missing a phase 2 External sync voltage out of range BOOLEAN 1=External sync voltage is out of range 3 External sync phase sequence incorrect BOOLEAN 1=The phase rotation on external sync is wrong 4 External sync frequency out of range BOOLEAN 1=External sync frequency is out of range 5 External sync missing phase BOOLEAN 1=External sync is missing a phase 6 External sync temporarily disabled BOOLEAN 1=External sync temporarily disabled 7 Flywheel inoperable BOOLEAN 1=Flywheel inoperable 8 Display firmware incompatibility detected BOOLEAN 1=Display firmware incompatibility detected 9 NMC 1 firmware incompatibility detected BOOLEAN 1=NMC 1 firmware incompatibility detected 10 NMC 2 firmware incompatibility detected BOOLEAN 1=NMC 2 firmware incompatibility detected 11 10-Inch display incompatibility detected BOOLEAN 1=10 inch Display firmware incompatibility detected 12 Inverter output is not in phase with bypass input BOOLEAN 1=Inverter output is not in phase with bypass input 13 Engineering Firmware Version detected BOOLEAN 1=Alarm Engineering Firmware Version detected 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40024 0x0017 23 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40025 0x0018 24 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40026 0x0019 25 Alarm Register 1 0 Sensor AP9810 - Input contact A in sensor 1 BOOLEAN 1 = Alarm from sensor 1 / contact A 1 Sensor AP9810 - Input contact B in sensor 1 BOOLEAN 1 = Alarm from sensor 1 / contact B 2 Sensor AP9810 - Input contact A in sensor 2 BOOLEAN 1 = Alarm from sensor 2 / contact A 3 Sensor AP9810 - Input contact B in sensor 2 BOOLEAN 1 = Alarm from sensor 2 / contact B 4 Sensor AP9335T or AP9335TH - temperature alarm in sensor 1 BOOLEAN 1 = temperature alarm in sensor 1 5 Sensor AP9335T or AP9335TH - temperature alarm in sensor 2 BOOLEAN 1 = temperature alarm in sensor 2 6 Sensor AP9335TH - humidity alarm in sensor 1 BOOLEAN 1 = humidity alarm in sensor 1 7 Sensor AP9335TH - humidity alarm in sensor 2 BOOLEAN 1 = humidity alarm in sensor 2 8 Sensor Communication Lost with sensor 1 BOOLEAN 1 = communication lost with sensor 1 9 Sensor Communication Lost with sensor 2 BOOLEAN 1= communication lost with sensor 2 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40027 0x0020 26 Alarm Register 1 0 Power Cabinet 1 surveillance detected a fault BOOLEAN 1 = Power Cabinet 1 surveillance detected a fault 1 Power Cabinet 2 surveillance detected a fault BOOLEAN 1 = Power Cabinet 2 surveillance detected a fault 2 Power Cabinet 3 surveillance detected a fault BOOLEAN 1 = Power Cabinet 3 surveillance detected a fault 3 Power Cabinet 4 surveillance detected a fault BOOLEAN 1 = Power Cabinet 4 surveillance detected a fault 4 Power Cabinet 5 surveillance detected a fault BOOLEAN 1 = Power Cabinet 5 surveillance detected a fault 5 Power Cabinet 6 surveillance detected a fault BOOLEAN 1 = Power Cabinet 6 surveillance detected a fault 6 Power Cabinet 7 surveillance detected a fault BOOLEAN 1 = Power Cabinet 7 surveillance detected a fault 7 Reserved BOOLEAN 8 Power Cabinet 1 inoperable BOOLEAN 1 = Power cabinet inoperable 9 Power Cabinet 2 inoperable BOOLEAN 1 = Power cabinet inoperable 10 Power Cabinet 3 inoperable BOOLEAN 1 = Power cabinet inoperable 11 Power Cabinet 4 inoperable BOOLEAN 1 = Power cabinet inoperable 12 Power Cabinet 5 inoperable BOOLEAN 1 = Power cabinet inoperable 13 Power Cabinet 6 inoperable BOOLEAN 1 = Power cabinet inoperable 14 Power Cabinet 7 inoperable BOOLEAN 1 = Power cabinet inoperable 15 Reserved BOOLEAN 40028 0x0021 27 Alarm Register 1 0 Input dry contact: Genset supplying UPS BOOLEAN 1= a Genset supply the UPS 1 Input dry contact: Battery room ventilation inoperable BOOLEAN 1= Battery room ventilation inoperable 2 Input dry contact: External battery monitoring inoperable BOOLEAN 1= External battery monitoring inoperable Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 3 Input dry contact: Ground fault detected BOOLEAN 1= Ground fault detected 4 Input dry contact: UPS locked in static bypass mode is actived BOOLEAN 1= UPS locked in static bypass mode is actived 5 Input dry contact: User-defined input dry contacts 1 BOOLEAN 1= User-defined input dry contacts 1, in alarm position 6 Input dry contact: User-defined input dry contacts 2 BOOLEAN 1= User-defined input dry contacts 2, in alarm position 7 Input dry contact: Flywheel inoperable BOOLEAN 1= Flywheel inoperable 8 Input dry contact: External energy storage monitoring major alarm BOOLEAN 1= External energy storage monitoring major alarm 9 Input dry contact: External energy storage monitoring minor alarm BOOLEAN 1= External energy storage monitoring minor alarm 10 Input dry contact: Force Charger Off BOOLEAN 1= Force Charger Off 11 Input dry contact: Disable High Efficiency Mode BOOLEAN 1= Disable High Efficiency Mode 12 Input dry contact: Transfer from Battery to Normal Operation delay BOOLEAN 1=Transfer from Battery to Normal Operation delay 13 Input dry contact: Force Battery Operation BOOLEAN 1=Force Battery Operation 14 Input dry contact: Request Bypass operation BOOLEAN 1=Requested Bypass command from input relay activated 15 Reserved BOOLEAN 40029 0x0022 28 Alarm Register 1 0 Power Cabinet 1 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 1 Power Cabinet 1 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 2 Power Cabinet 1 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 3 Power Cabinet 1 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 4 Power Cabinet 1 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 5 Power Cabinet 1 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 6 Power Cabinet 1 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 7 Power Cabinet 1 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 8 Power Cabinet 2 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 9 Power Cabinet 2 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 10 Power Cabinet 2 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 11 Power Cabinet 2 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 12 Power Cabinet 2 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 13 Power Cabinet 2 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 14 Power Cabinet 2 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 15 Power Cabinet 2 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 40030 0x0023 29 Alarm Register 1 0 Power Cabinet 3 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 1 Power Cabinet 3 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 2 Power Cabinet 3 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 3 Power Cabinet 3 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 4 Power Cabinet 3 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 5 Power Cabinet 3 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 6 Power Cabinet 3 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 7 Power Cabinet 3 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 8 Power Cabinet 4 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 9 Power Cabinet 4 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 10 Power Cabinet 4 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 11 Power Cabinet 4 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 12 Power Cabinet 4 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 13 Power Cabinet 4 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 14 Power Cabinet 4 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 15 Power Cabinet 4 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 40031 0x0024 30 Alarm Register 1 0 Power Cabinet 5 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 1 Power Cabinet 5 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 2 Power Cabinet 5 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 3 Power Cabinet 5 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 4 Power Cabinet 5 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 5 Power Cabinet 5 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 6 Power Cabinet 5 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 7 Power Cabinet 5 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 8 Power Cabinet 6 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 9 Power Cabinet 6 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 10 Power Cabinet 6 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 11 Power Cabinet 6 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 12 Power Cabinet 6 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 13 Power Cabinet 6 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 14 Power Cabinet 6 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 15 Power Cabinet 6 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 40032 0x0025 31 Alarm Register 1 Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 0 Power Cabinet 7 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 1 Power Cabinet 7 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 2 Power Cabinet 7 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 3 Power Cabinet 7 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 4 Power Cabinet 7 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 5 Power Cabinet 7 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 6 Power Cabinet 7 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 7 Power Cabinet 7 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 8 Reserved BOOLEAN 9 Surveillance Limit Detected on Power Cabinet 1 BOOLEAN 1= SurvLimitDetected on Power Cabinet 1 10 Surveillance Limit Detected on Power Cabinet 2 BOOLEAN 1= SurvLimitDetected on Power Cabinet 2 11 Surveillance Limit Detected on Power Cabinet 3 BOOLEAN 1= SurvLimitDetected on Power Cabinet 3 12 Surveillance Limit Detected on Power Cabinet 4 BOOLEAN 1= SurvLimitDetected on Power Cabinet 4 13 Surveillance Limit Detected on Power Cabinet 5 BOOLEAN 1= SurvLimitDetected on Power Cabinet 5 14 Surveillance Limit Detected on Power Cabinet 6 BOOLEAN 1= SurvLimitDetected on Power Cabinet 6 15 Surveillance Limit Detected on Power Cabinet 7 BOOLEAN 1= SurvLimitDetected on Power Cabinet 7 Static Data 44097 0x1000 4096 Display/NMC Model Number 9 ASCII 44106 0x1009 4105 Display/NMC Serial Number 8 ASCII 44114 0x1011 4113 Display/NMC Firmware Revision APP 9 ASCII 44123 0x101A 4122 Display/NMC Hardware Revision 9 ASCII 44132 0x1023 4131 Display/NMC Date of Manufacture 6 ASCII 44138 0x1029 4137 RESERVED 8 44146 0x1031 4145 UPS Serial Number 6 ASCII 44152 0x1037 4151 UPS Firmware Version 12 ASCII 44164 0x1043 4163 Product Name 40 ASCII 44204 0x106B 4203 UPS Serial Number for 14 characters 8 ASCII for new 3-phases UPS, using 14 characters Dynamic Data 44353 0x1100 4352 RESERVED 2 44355 0x1102 4354 Runtime remaining 2 UINT32 1 1 Seconds 44357 0x1104 4356 Estimated charge time 2 UINT32 1 1 Seconds 44359 0x1106 4358 Estimated charge % 1 UINT16 1 1 % 44360 0x1107 4359 RESERVED 8 44368 0x110F 4367 Battery Temperature (for classic battery solution) 1 UINT16 1 1 °C or °F 44369 0x1110 4368 Charger Mode 1 0 Float Charging BOOLEAN 1=Charger mode is float charging 1 Boost Charging BOOLEAN 1=Charger mode is boost charging 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Equalization Charging BOOLEAN 1=Charger mode is eqalization charging 6 Not Charging BOOLEAN 1=Charger mode is Off 7 Test In Progress BOOLEAN 1=Test is in progress 8 Cyclic Charging BOOLEAN 1=Charge mode is cyclic charging 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 44370 0x1111 4369 Battery Power 1 UNIT16 0.1 10 kW 44371 0x1112 4370 RESERVED 1 44372 0x1113 4371 Battery Voltage 1 UINT16 0.1 10 Vdc 44373 0x1114 4372 Battery Current, for GVX up to 1000kVA 1 UINT16 0.1 10 Amps - Caution overflow possible. There is a current limitation [– 3276A, 3276A]. That register can be use for GVX up to 1000KVA. When GVX power rating exceed 1000 kVA (1250KVA and 1500kVA) used register 0x111D 44374 0x1115 4373 RESERVED 1 UINT16 1 1 44375 0x1116 4374 RESERVED 1 UINT16 1 1 44376 0x1117 4375 RESERVED 1 UINT16 1 1 44377 0x1118 4376 RESERVED 1 UINT16 1 1 44378 0x1119 4377 RESERVED 1 UINT16 1 1 44379 0x111A 4378 RESERVED 1 UINT16 1 1 44380 0x111B 4379 RESERVED 1 UINT16 1 1 44381 0x111C 4380 RESERVED 1 UINT16 1 1 Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 44382 0x111D 4381 Battery Current, for all GVX power rating (from 250kVA up to 1500kVA) 1 UNT16 1 1 Amps - Recommended register for GVX. To be used when UPS power rating exceed 1000 kVA. This register supports all GVX power rating (from 250KVA up to 1500kVA). 44383 0x111E 4382 Battery Test Process Status ENUM 0= Inactive 1= Battery Calibration is In Progress 2= Battery Calibration is Passed 5= Battery Calibration is Aborted 44384 0x111F 4383 Battery Calibration Process Status ENUM 0= Inactive 1= Battery Calibration is In Progress 2= Battery Calibration is Passed 5= Battery Calibration is Aborted 44385 0x1120 4384 Battery Test Status ENUM 0= Unknown 1= Battery OK 2= Battery CapacityReduced 3= Battery Defect 44609 0x1200 4608 Frequency (input) 1 UINT16 0.1 10 Hz 44610 0x1201 4609 Voltage L1-2 (input) 1 UINT16 1 1 Volts 44611 0x1202 4610 Voltage L2-3 (input) 1 UINT16 1 1 Volts 44612 0x1203 4611 Voltage L3-1 (input) 1 UINT16 1 1 Volts 44613 0x1204 4612 Current L1 (input) 1 UINT16 1 1 amps 44614 0x1205 4613 Current L2 (input) 1 UINT16 1 1 amps 44615 0x1206 4614 Current L3 (input) 1 UINT16 1 1 amps 44616 0x1207 4615 Active power L1 (input) 1 UINT16 1 1 kW 44617 0x1208 4616 Active power L2 (input) 1 UINT16 1 1 kW 44618 0x1209 4617 Active power L3 (input) 1 UINT16 1 1 kW 44619 0x120A 4618 Apparent power L1 (input) 1 UINT16 1 1 kVA 44620 0x120B 4619 Apparent power L2 (input) 1 UINT16 1 1 kVA 44621 0x120C 4620 Apparent power L3 (input) 1 UINT16 1 1 kVA 44622 0x120D 4621 Total active power (input) 1 UINT16 1 1 kW 44623 0x120E 4622 Total apparent power (input) 1 UINT16 1 1 kVA 44624 0x120F 4623 Voltage L1-N (input) 1 UINT16 1 1 Volts 44625 0x1210 4624 Voltage L2-N (input) 1 UINT16 1 1 Volts 44626 0x1211 4625 Voltage L3-N (input) 1 UINT16 1 1 Volts 44627 0x1212 4626 Maximum RMS Current L1 (input) 2 UINT32 1 1 amps 44629 0x1214 4628 Maximum RMS Current L2 (input) 2 UINT32 1 1 amps 44631 0x1216 4630 Maximum RMS Current L3 (input) 2 UINT32 1 1 amps 44633 0x1218 4632 Power factor L1 (input) 1 UINT16 0.01 100 Unitless 44634 0x1219 4633 Power factor L2 (input) 1 UINT16 0.01 100 Unitless 44635 0x121A 4634 Power factor L3 (input) 1 UINT16 0.01 100 Unitless 44865 0x1300 4864 Frequency (bypass) 1 UINT16 0.1 10 Hz 44866 0x1301 4865 Voltage L1-2 (bypass) 1 UINT16 1 1 Volts 44867 0x1302 4866 Voltage L2-3 (bypass) 1 UINT16 1 1 Volts 44868 0x1303 4867 Voltage L3-1 (bypass) 1 UINT16 1 1 Volts 44869 0x1304 4868 Current L1 (bypass) 1 UINT16 1 1 amps 44870 0x1305 4869 Current L2 (bypass) 1 UINT16 1 1 amps 44871 0x1306 4870 Current L3 (bypass) 1 UINT16 1 1 amps 44872 0x1307 4871 Active power L1 (bypass) 1 UINT16 1 1 kW 44873 0x1308 4872 Active power L2 (bypass) 1 UINT16 1 1 kW 44874 0x1309 4873 Active power L3 (bypass) 1 UINT16 1 1 kW 44875 0x130A 4874 Apparent power L1 (bypass) 1 UINT16 1 1 kVA 44876 0x130B 4875 Apparent power L2 (bypass) 1 UINT16 1 1 kVA 44877 0x130C 4876 Apparent power L3 (bypass) 1 UINT16 1 1 kVA 44878 0x130D 4877 Total active power (bypass) 1 UINT16 1 1 kW 44879 0x130E 4878 Total apparent power (bypass) 1 UINT16 1 1 kVA 44880 0x130F 4879 Voltage L1-N (bypass) 1 UINT16 1 1 Volts 44881 0x1310 4880 Voltage L2-N (bypass) 1 UINT16 1 1 Volts 44882 0x1311 4881 Voltage L3-N (bypass) 1 UINT16 1 1 Volts 44883 0x1312 4882 Maximum RMS Current L1 (bypass) 2 UINT32 1 1 amps 44885 0x1314 4884 Maximum RMS Current L2 (bypass) 2 UINT32 1 1 amps 44887 0x1316 4886 Maximum RMS Current L3 (bypass) 2 UINT32 1 1 amps 44889 0x1318 4888 Power factor L1 (bypass) 1 UINT16 0.01 100 Unitless 44890 0x1319 4889 Power factor L2 (bypass) 1 UINT16 0.01 100 Unitless 44891 0x131A 4890 Power factor L3 (bypass) 1 UINT16 0.01 100 Unitless 44892 0x131B 4891 UTHD - Voltage THD L1 (bypass) 1 UINT16 0.1 10 % 44893 0x131C 4892 UTHD - Voltage THD L2 (bypass) 1 UINT16 0.1 10 % 44894 0x131D 4893 UTHD - Voltage THD L3 (bypass) 1 UINT16 0.1 10 % 45121 0x1400 5120 UPS Power Rating 1 UINT16 1 1 kVA 45122 0x1401 5121 Frequency (output) 1 UINT16 0.1 10 Hz 45123 0x1402 5122 Voltage L1-2 (output) 1 UINT16 1 1 Volts Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 45124 0x1403 5123 Voltage L2-3 (output) 1 UINT16 1 1 Volts 45125 0x1404 5124 Voltage L3-1 (output) 1 UINT16 1 1 Volts 45126 0x1405 5125 Current L1 (output) 1 UINT16 1 1 amps 45127 0x1406 5126 Current L2 (output) 1 UINT16 1 1 amps 45128 0x1407 5127 Current L3 (output) 1 UINT16 1 1 amps 45129 0x1408 5128 Maximum RMS current L1 (output) 2 UINT32 1 1 amps 45131 0x140A 5130 Maximum RMS current L2 (output) 2 UINT32 1 1 amps 45133 0x140C 5132 Maximum RMS current L3 (output) 2 UINT32 1 1 amps 45135 0x140E 5134 Active power L1 (output) 1 UINT16 1 1 kW 45136 0x140F 5135 Active power L2 (output) 1 UINT16 1 1 kW 45137 0x1410 5136 Active power L3 (output) 1 UINT16 1 1 kW 45138 0x1411 5137 Apparent power L1 (output) 1 UINT16 1 1 kVA 45139 0x1412 5138 Apparent power L2 (output) 1 UINT16 1 1 kVA 45140 0x1413 5139 Apparent power L3 (output) 1 UINT16 1 1 kVA 45141 0x1414 5140 Apparent power percent L1 (output) 1 UINT16 0.1 10 % 45142 0x1415 5141 Apparent power percent L2 (output) 1 UINT16 0.1 10 % 45143 0x1416 5142 Apparent power percent L3 (output) 1 UINT16 0.1 10 % 45144 0x1417 5143 Total active power (output) 1 UINT16 1 1 kW 45145 0x1418 5144 Total apparent power (output) 1 UINT16 1 1 kVA 45146 0x1419 5145 Total Output Percent load 1 UINT16 0.1 10 % 45147 0x141A 5146 Power factor L1 (output) 1 UINT16 0.01 100 power factor 45148 0x141B 5147 Power factor L2 (output) 1 UINT16 0.01 100 power factor 45149 0x141C 5148 Power factor L3 (output) 1 UINT16 0.01 100 power factor 45150 0x141D 5149 Current crest factor L1 (output) 1 UINT16 0.1 10 crest factor 45151 0x141E 5150 Current crest factor L2 (output) 1 UINT16 0.1 10 crest factor 45152 0x141F 5151 Current crest factor L3 (output) 1 UINT16 0.1 10 crest factor 45153 0x1420 5152 Voltage L1-N (output) 1 UINT16 1 1 Volts 45154 0x1421 5153 Voltage L2-N (output) 1 UINT16 1 1 Volts 45155 0x1422 5154 Voltage L3-N (output) 1 UINT16 1 1 Volts 45156 0x1423 5155 Neutral current (output) 1 UINT16 1 1 amps 45157 0x1424 5156 Current THD L1 (output) 1 UINT16 0.1 10 % 45158 0x1425 5157 Current THD L2 (output) 1 UINT16 0.1 10 % 45159 0x1426 5158 Current THD L3 (output) 1 UINT16 0.1 10 % 45160 0x1427 5159 IOC Power Rating 1 UINT16 1 1 kVA 45161 0x1428 5160 Available UPS Power Rating 1 UINT16 1 1 kVA 45376 0x14FF 5375 RESERVED 1 UINT16 1 1 45377 0x1500 5376 IOC Ambient temperature 1 UINT16 1 1 °C or °F 45378 0x1501 5377 Switch gear status 1 Bit mask For each bit, 0 = open, 1 =closed 0 Unit Input Breaker (UIB) BOOLEAN 1 Unit Output Breaker (UOB) BOOLEAN 2 Maintenance Bypass Breaker (MBB) BOOLEAN 3 System Isolation Breaker (SIB) BOOLEAN 4 Static Switch Input Breaker (SSIB) BOOLEAN 5 Battery Breaker 1 (for classic battery solution) BOOLEAN 6 Battery Breaker 2 (for classic battery solution) BOOLEAN 7 Battery Breaker 3 (for classic battery solution) BOOLEAN 8 Battery Breaker 4 (for classic battery solution) BOOLEAN 9 BF2 BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 45379 0x1502 5378 UPS Operation Mode 1 ENUM 1 = Normal operation 2 = Battery Operation 3 = Battery Test 4 = Requested Static Bypass 5 = Forced Static Bypass 6 = Maintenance Bypass 7 = Off 8 = Emergency Static Bypass 9 = Static Bypass Standby 10 = Inverter Standby 11 = Power Saving Mode 12 = Inverter SPoT Mode 13 = ECO Mode 14 = ECOnversion 45380 0x1503 5379 Number of Active Alarms 1 UINT16 1 1 Number of active alarms in the system 45381 0x1504 5380 Highest alarm severity 1 UINT16 1 1 0 = none 1 = informational 2 = warning 3 = critical 45382 0x1505 5381 System Mode 1 ENUM 1 = Inverter 2 = Requested Static Bypass 3 = Forced Static Bypass 4 = Off 5 = Reserved 6 = Maintenance Bypass 7 = ECO Mode 45383 0x1506 5382 RESERVED 3 45385 0x1508 5384 UPS Redundancy Status 1 UINT16 1 1 45386 0x1509 5385 NMC/UPS Time 4 ASCII hh:mm:ss format 45390 0x150D 5389 NMC/UPS Date 5 ASCII mm/dd/yyyy format 45395 0x1512 5394 Input kWh 2 UINT32 1 1 kWh 45397 0x1514 5396 Output kWh 2 UINT32 1 1 kWh 45399 0x1516 5398 IOC Exhaust Air Temperature 1 UINT16 1 1 °C or °F 45400 0x1517 5399 Ambient Temperature from Power Cabinet [1] 1 UINT16 1 1 °C or °F 45401 0x1518 5400 Exhaust Temperature from Power Cabinet [1] 1 UINT16 1 1 °C or °F 45402 0x1519 5401 Ambient Temperature from Power Cabinet [2] 1 UINT16 1 1 °C or °F 45403 0x151A 5402 Exhaust Temperature from Power Cabinet [2] 1 UINT16 1 1 °C or °F 45404 0x151B 5403 Ambient Temperature from Power Cabinet [3] 1 UINT16 1 1 °C or °F 45405 0x151C 5404 Exhaust Temperature from Power Cabinet [3] 1 UINT16 1 1 °C or °F 45406 0x151D 5405 Ambient Temperature from Power Cabinet [4] 1 UINT16 1 1 °C or °F 45407 0x151E 5406 Exhaust Temperature from Power Cabinet [4] 1 UINT16 1 1 °C or °F 45408 0x151F 5407 Ambient Temperature from Power Cabinet [5] 1 UINT16 1 1 °C or °F 45409 0x1520 5408 Exhaust Temperature from Power Cabinet [5] 1 UINT16 1 1 °C or °F 45410 0x1521 5409 Ambient Temperature from Power Cabinet [6] 1 UINT16 1 1 °C or °F 45411 0x1522 5410 Exhaust Temperature from Power Cabinet [6] 1 UINT16 1 1 °C or °F 45412 0x1523 5411 Ambient Temperature from Power Cabinet [7] 1 UINT16 1 1 °C or °F 45413 0x1524 5412 Exhaust Temperature from Power Cabinet [7] 1 UINT16 1 1 °C or °F 45414 0x1525 5413 Power Cabinet Redundancy Status 1 UINT16 1 1 0 - 7 46401 0x1900 6400 Current L1 (parallel system mains input) 1 UINT16 1 1 amps 46402 0x1901 6401 Current L2 (parallel system mains input) 1 UINT16 1 1 amps 46403 0x1902 6402 Current L3 (parallel system mains input) 1 UINT16 1 1 amps 46404 0x1903 6403 Current L1 (parallel system bypass input) 1 UINT16 1 1 amps 46405 0x1904 6404 Current L2 (parallel system bypass input) 1 UINT16 1 1 amps 46406 0x1905 6405 Current L3 (parallel system bypass input) 1 UINT16 1 1 amps 46407 0x1906 6406 Current L1 (parallel system output) 1 UINT16 1 1 amps 46408 0x1907 6407 Current L2 (parallel system output) 1 UINT16 1 1 amps 46409 0x1908 6408 Current L3 (parallel system output) 1 UINT16 1 1 amps 46410 0x1909 6409 Total apparent power (parallel system output) 1 UINT16 1 1 kVA 46411 0x190A 6410 Total Percent load (parallel system) 1 UINT16 0.1 10 % 46412 0x190B 6411 Total active power (parallel system output) 1 UINT16 1 1 kW 46413 0x190C 6412 Apparent power percent L1 (parallel system output) 1 UINT16 0.1 10 % 46414 0x190D 6413 Apparent power percent L2 (parallel system output) 1 UINT16 0.1 10 % 46415 0x190E 6414 Apparent power percent L3 (parallel system output) 1 UINT16 0.1 10 % 46416 0x190F 6415 Reserved 46417 0x1910 6416 Reserved 46418 0x1911 6417 Reserved 46419 0x1912 6418 Reserved 46420 0x1913 6419 UPS Operation Modes 1 bit = 1, define current UPS operation mode Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 0 Initialize BOOLEAN 1 Normal Operation BOOLEAN 2 Battery Operation BOOLEAN 3 Battery test or Battery Discharge in Spot Mode BOOLEAN 4 Requested Static Bypass BOOLEAN 5 Forced Static Bypass BOOLEAN 6 Maintenance Bypass BOOLEAN 7 Off BOOLEAN 8 Emergency Static Bypass BOOLEAN 9 Static Bypass Standby BOOLEAN 10 Inverter standby BOOLEAN 11 Power Saving mode BOOLEAN 12 Inverter SPoT Mode BOOLEAN 13 ECO mode BOOLEAN 14 ECOnvertion Mode mode BOOLEAN 15 Charger SPoT Mode BOOLEAN 46421 0x1914 6420 System Mode 1 bit = 1, define current System mode 0 Inverter BOOLEAN 1 Requested Static Bypass BOOLEAN 2 Forced Static Bypass BOOLEAN 3 Off BOOLEAN 4 Maintenance Bypass BOOLEAN 5 ECO mode BOOLEAN 6 ECOnversion mode BOOLEAN 7 Static Bypass Standby Operation BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 46422 0x1915 6421 Reserved 1 UINT16 1 1 46423 0x1916 6422 Reserved 1 UINT16 1 1 46424 0x1917 6423 Reserved 1 UINT16 1 1 46425 0x1918 6424 Reserved 1 UINT16 1 1 46426 0x1919 6425 Reserved 1 UINT16 1 1 46427 0x191A 6426 Reserved 1 UINT16 1 1 46428 0x191B 6427 Reserved 1 UINT16 1 1 46429 0x191C 6428 Reserved 1 UINT16 1 1 46430 0x191D 6429 Reserved 1 UINT16 1 1 46431 0x191E 6430 Sensor temperature in sensor 1 1 UINT16 0.1 10 °C or °F 46432 0x191F 6431 Sensor temperature in sensor 2 1 UINT16 0.1 10 °C or °F 46433 0x1920 6432 Sensor humidity in sensor 1 1 UINT16 0.1 10 % 46434 0x1921 6433 Sensor humidity in sensor 2 1 UINT16 0.1 10 % 46435 0x1922 6434 Sensor (AP9810) input contact status 1 Bit mask For each bit, 0 = open, 1 =closed 0 Sensor dry contact A in sensor 1 BOOLEAN 1 Sensor dry contact B in sensor 1 BOOLEAN 2 Sensor dry contact A in sensor 2 BOOLEAN 3 Sensor dry contact B in sensor 2 BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 46449 0x1930 6448 User interface - Input Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 46450 0x1931 6449 User interface - PFC Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46451 0x1932 6450 User interface - Battery Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46452 0x1933 6451 User interface - Inverter Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46453 0x1934 6452 User interface - Output Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46454 0x1935 6453 User interface - Bypass Input Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46455 0x1936 6454 User interface - Static Bypass Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46456 0x1937 6455 Status for mimic animation 1 UINT16 1 1 0 Aggregated Battery circuit breaker status BOOLEAN 0 = open, 1 =closed 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 46457 0x1938 6456 Power Cabinet status for UPS detailled view animation 1 UINT16 1 1 0 Warning alarm present in Power Cabinet 1 BOOLEAN 1 = warning alarm present in Power Cabinet 1 (Orange) 1 Critical alarm present in Power Cabinet 1 BOOLEAN 1 = critical alarm present Power Cabinet 1 (Red) 2 Warning alarm present in Power Cabinet 2 BOOLEAN 1 = warning alarm present in Power Cabinet 2 (Orange) 3 Critical alarm present in Power Cabinet 2 BOOLEAN 1 = critical alarm present Power Cabinet 2 (Red) 4 Warning alarm present in Power Cabinet 3 BOOLEAN 1 = warning alarm present in Power Cabinet 3 (Orange) 5 Critical

alarm present in Power Cabinet 3 BOOLEAN 1 = critical alarm present Power Cabinet 3 (Red) 6 Warning alarm present in Power Cabinet 4 BOOLEAN 1 = warning alarm present in Power Cabinet 4 (Orange) 7 Critical alarm present in Power Cabinet 4 BOOLEAN 1 = critical alarm present Power Cabinet 4 (Red) 8 Warning alarm present in Power Cabinet 5 BOOLEAN 1 = warning alarm present in Power Cabinet 5 (Orange) 9 Critical alarm present in Power Cabinet 5 BOOLEAN 1 = critical alarm present Power Cabinet 5 (Red) 10 Warning alarm present in Power Cabinet 6 BOOLEAN 1 = warning alarm present in Power Cabinet 6 (Orange) 11 Critical alarm present in Power Cabinet 6 BOOLEAN 1 = critical alarm present Power Cabinet 6 (Red) 12 Warning alarm present in Power Cabinet 7 BOOLEAN 1 = warning alarm present in Power Cabinet 7 (Orange) 13 Critical alarm present in Power Cabinet 7 BOOLEAN 1 = critical alarm present Power Cabinet 7 (Red) 14 Reserved BOOLEAN 15 Reserved BOOLEAN 46458 0x1939 6457 Power Cabinet status for UPS detailed view animation 1 UINT16 1 1 0 informational alarm present in Power Cabinet 1 BOOLEAN 1 = informational alarm present Power Cabinet 1 1 informational alarm present in Power Cabinet 2 BOOLEAN 1 = informational alarm present in Power Cabinet 2 2 informational alarm present in Power Cabinet 3 BOOLEAN 3 = informational alarm present in Power Cabinet 3 3 informational alarm present in Power Cabinet 4 BOOLEAN 4 = informational alarm present in Power Cabinet 4 4 informational alarm present in Power Cabinet 5 BOOLEAN 5 = informational alarm present in Power Cabinet 5 5 informational alarm present in Power Cabinet 6 BOOLEAN 6 = informational alarm present in Power Cabinet 6 6 informational alarm present in Power Cabinet 7 BOOLEAN 7 = informational alarm present in Power Cabinet 7 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 14 Reserved BOOLEAN 15 Reserved BOOLEAN Configuratio n Data 48193 0x2000 8192 RESERVED 3 48196 0x2003 8195 RESERVED 1 48198 0x2005 8197 RESERVED 48199 0x2006 8198 RESERVED 48200 0x2007 8199 Breaker settings 1 bit = 1, breaker is present 0 breaker Q1 (UIB) BOOLEAN 1 breaker Q2 (UOB) BOOLEAN 2 Q3 (MBB) BOOLEAN 3 Q4 (SIB) BOOLEAN 4 Q5 (SSIB) BOOLEAN 5 BB1 BOOLEAN 6 BB2 BOOLEAN 7 BB3 BOOLEAN 8 BB4 BOOLEAN 9 BF2 BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 48201 0x2008 8200 Temperature unity 1 ENUM 0 = Celcius 1 = Fahrenheit 48202 0x2009 8201 UPS environment settings 1 0 Input transformer presence BOOLEAN bit = 1, transformer is present 1 Output transformer presence BOOLEAN bit = 1, transformer is present 2 AC wiring configuration BOOLEAN bit = 0, input cabling 3 wires bit = 1, input cabling 4 wires 3 UPS mains supply by single input BOOLEAN bit = 1, mains supply input is single 4 UPS mains supply by dual input BOOLEAN bit = 1, mains supply input is dual 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 48203 0x200A 8202 SIB breaker label 2 ASCII 4 bytes string = 2 registers, Default value "SIB " 48205 0x200C 8204 UIB breaker label 2 ASCII 4 bytes string = 2 registers, Default value "UIB " 48207 0x200E 8206 SSIB breaker label 2 ASCII 4 bytes string = 2 registers, Default value "SSIB" 48209 0x2010 8208 MBB breaker label 2 ASCII 4 bytes string = 2 registers, Default value "MBB " 48211 0x2012 8210 UOB breaker label 2 ASCII 4 bytes string = 2 registers, Default value "UOB " 48213 0x2014 8212 BF2 breaker label 2 ASCII 4 bytes string = 2 registers, Default value "BF2 " 48215 0x2016 8214 BB breaker label 2 ASCII 4 bytes string = 2 registers, Default value "BB " 48217 0x2018 8216 UPS Name 9 ASCII 18 bytes string = 9 registers 48449 0x2100 8448 Low Battery Alarm Threshold 1 UINT16 1 1 Seconds 48450 0x2101 8449 Battery Type 1 ENUM 1 1 0=VRLA 1=Open Cell 2=Lithium-Ion 3=NiCd 6=NiZn 48451 0x2102 8450 Battery Solution 1 ENUM 1 1 0=None 1=Classic 2=NA 3=Unknown 48452 0x2103 8451 Deep Discharge Allowed 1 ENUM 1 1 0=No 1=Yes 48453 0x2104 8452 Total Battery Capacity 1 UINT16 1 1 Ah 48454 0x2105 8453 Reserved 1 UINT16 1 1 48455 0x2106 8454 Number of battery bank for Classical battery 1 UINT16 1 1 Unitless Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 48705 0x2200 8704 Nominal Output Voltage 1 ENUM 1 1 0=380V 1=400V 2=415V 3=480V 4=440V 48706 0x2201 8705 Transfer to Static Bypass Disable 1 ENUM 1 1 0=Disable 1=Enable 48707 0x2202 8706 Reserved 1 ENUM 1 1 48708 0x2203 8707 Automatic Battery Disconnect 1 ENUM 1 1 0=No 1=Yes 48709 0x2204 8708 High Efficiency Mode 1 ENUM 1 1 0=Disable 1=ECO mode 2=EConversion 3=EConversion Harmonics Compensator 48710 0x2205 8709 Reserved 1 1 1 48711 0x2206 8710 Number of UPS installed in a parallel installation 1 UINT16 48712 0x2207 8711 Number of redundant UPS installed in a parallel installatio 1 UINT16 48713 0x2208 8712 Number of redundant Power Cabinet installed in a UPS 1 UINT16 48714 0x2209 8713 UPSs presence in parallel installation 1 0 UPS 1 presence BOOLEAN bit = 0, UPS 1 not present bit = 1, UPS 1 present 1 UPS 2 presence BOOLEAN bit = 0, UPS 2 not present bit = 1, UPS 2 is present 2 UPS 3 presence BOOLEAN bit = 0, UPS 3 not present bit = 1, UPS 3 is present 3 UPS 4 presence BOOLEAN bit = 0, UPS 4 not present bit = 1, UPS 4 is present 4 UPS 5 presence BOOLEAN bit = 0, UPS 5 not present bit = 1, UPS 5 is present 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 48715 0x220A 8714 Frequency Converter Mode 1 ENUM 1 1 0=Disable 1=Enable 48716 0x220B 8715 Energy Storage Type 1 ENUM 1 1 0=None 1=Battery 2=Flywheel48717 0x220C 8716 Number Power Cabinet on the left of IO Cabinet 1 UINT16 1 1 48718 0x220D 8717 Continuous Overload Mode Setting 1 UINT16 1 1 % Worldwide Customer Support Customer support for this or any other product is available at no charge in any of the following ways: * Visit the Schneider Electric Web site to access documents in the Schneider Electric Knowledge Base and to submit customer support requests. – www.schneider-electric.com (Corporate Headquarters) Connect to localized Schneider Electric Web sites for specific countries, each of which provides customer support information. – www.schneider-electric.com/support/ Global support searching Schneider Electric Knowledge Base and using e-support. * Contact the Schneider Electric Customer Support Center by telephone or e-mail. – Local, country-specific centers: go to www.schneider-electric.com > Support > Operations around the world for contact information. SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System Product Environmental Profile Galaxy VX UPS System #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System 3600 kg Plastics Metals Others 22.70% General information Reference product Galaxy VX 1250kVA, 400V, Start up 5x8 - GVX1250K1250NHS Constituent materials This document provides environmental impact and performance of the product based on Life Cycle Assessment (LCA), from cradle to grave (materials, manufacturing, distribution, installation, use and end of life). Reference product mass including the product, its packaging and additional elements and accessories 4.80% 72.50% Description of the product The Galaxy VX is a scalable, highly efficient 500 - 1500KVA 3 phase Uninterruptible Power Supply (UPS) system that provides seamless power protection for large sized data centers, industrial and facilities applications. Description of the range Galaxy VX UPS System The representative product is 1250 kW rating (5 Power Cabinets) with 1250 kW I/O Cabinet (GVX1250K1250NHS). The environmental impacts of this referenced product are representative of the impacts of the other products of the range which are developed with a similar technology. Meanwhile, environmental details of other kVA ratings are available in supplementary information at the end of this document. Functional unit To protect the load of 1250 kW against input power failure during 15 years and switch to the energy storage system to avoid power outage. Steel - 42% Copper - 16.6% Aluminium - 12.8% Tin - 0.5% Ferrous alloys - 0.3% Brass - 0.3% Electronic components - 16.6% Wood - 3.6% Cardboard - 1.3% Miscellaneous - 0.4% Various - 0.8% PC Polycarbonate - 2.6% UP Polyester - 0.5% PE Polyethylene - 0.5% PA Polyamide - 0.4% Diverse Thermosetting Plastics - 0.4% ABS Acrylonitrile Butadiene Styrene - 0.4% #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System RoHS compliance REACH compliance Battery Directive compliance End Of Life 76% Use scenario Power consumption conforms to the requirements in PSR0010-ed1.1-EN-2015_10_16_UPS: The referent UPS can operate in 2 modes. It has an average energy efficiency of 95.8% in Double Conversion mode and 98.6% in eConversion mode. Total energy losses are calculated to be 3418454 kWh in Double Conversion and 1047094 kWh in eConversion after 15 years. Geographical representativeness Europe Energy model used [A1 - A3] [A5] [B6] [C1 - C4] Electricity Mix; Production mix; Low voltage; IN Electricity Mix; Production mix; Low voltage; UE-27 Electricity Mix; Production mix; Low voltage; UE-27 Electricity Mix; Production mix; Low voltage; UE-27 Technological representativeness The Modules of Technologies such as material production, manufacturing process and transport technology used in this PEP analysis (LCA- EIME in this case) are Similar and representative of the actual type of technologies used to make the product in production. Environmental impacts Reference service life time 15 years Installation elements The disposal of the packaging materials is accounted for 6% during the installation phase (including transport to disposal). Substance assessment Details of ROHS and REACH substances information are available on the Schneider-Electric Green Premium website https://www.se.com/ww/en/work/support/green-premium/ Additional environmental information Recyclability potential: Recyclability rate has been calculated based on REEECY'LAB tool developed by Ecosystem, for components/materials not covered by the tool, data from the "ECO'DEEE recyclability and recoverability calculation method" was taken. If no data was found a conservative assumption was used (0% recyclability). Products of this range are designed in conformity with the requirements of the RoHS directive (European Directive 2011/65/EU of 8 June 2011) on restriction of lead, mercury, cadmium, hexavalent chromium or flame retardants -PBB&PBDE or phthalates-DEHP, BBP, DBP, DIBP. Products of this range are designed in conformity with the requirements of the REACH 1907/2006 regulation and its latest updates. The battery within this product range are designed in conformity with the requirements of the Battery and Accumulator Directive (European Directive 2006/66/EC of 26 September 2006) Average energy efficiency Electricity consumption (kWh over 15 years) 500 kW with 1250 kW I/O Cabinet 95.6% 1.45E+06 98.6% 4.52E+05 625 kW with 1250 kW I/O Cabinet 95.6% 1.81E+06 98.6% 6.78E+05 750 kW with 1250 kW I/O Cabinet 95.6% 2.17E+06 98.4% 7.51E+05 800 kW with 1250 kW I/O Cabinet 95.7% 2.23E+06 98.3% 8.02E+05 1000 kW with 1250 kW I/O Cabinet 95.8% 2.76E+06 98.6% 8.71E+05 1000 kW with 1500 kW I/O Cabinet 95.8% 2.98E+06 98.6% 9.58E+05 1250 kW with 1250 kW I/O Cabinet 95.8% 3.42E+06 98.6% 1.05E+06 500 kW with 1500 kW I/O Cabinet 96.4% 1.19E+06 99.0% 3.20E+05 750 kW with 1500 kW I/O Cabinet 96.2% 1.90E+06 98.9% 5.05E+05 1000 kW with 1500 kW I/O Cabinet 96.0% 2.65E+06 98.9% 6.73E+05 1250 kW with 1500 kW I/O Cabinet 96.2% 3.20E+06 99.0% 7.60E+05 1500 kW with 1500 kW I/O Cabinet 96.2% 3.84E+06 99.0% 9.12E+05 Type (400V UPS system) Double conversion eConversionAverage energy efficiency Electricity consumption (kWh over 15 years) 500 kW with 1250 kW I/O Cabinet 95.7% 1.38E+06 98.0% 5.83E+05 625 kW with 1250 kW I/O Cabinet 95.7% 1.61E+06 98.2% 6.78E+05 750 kW with 1250 kW I/O Cabinet 95.9% 1.98E+06 98.4% 7.51E+05 800 kW with 1250 kW I/O Cabinet 95.9% 2.08E+06 98.3% 8.02E+05 1000 kW with 1250 kW I/O Cabinet 96.1% 2.51E+06 98.6% 8.46E+05 1100 kW with 1250 kW I/O Cabinet 96.2% 2.68E+06 98.5% 9.67E+05 1250 kW with 1250 kW I/O Cabinet 96.2% 3.08E+06 98.6% 1.06E+06 500 kW with 1500 kW I/O Cabinet 96.2% 1.23E+06 98.9% 3.20E+05 750 kW with 1500 kW I/O Cabinet 96.3% 1.80E+06 98.9% 5.05E+05 1000 kW with 1500 kW I/O Cabinet 96.3% 2.37E+06 98.9% 6.73E+05 1250 kW with 1500 kW I/O Cabinet 96.4% 2.92E+06 99.0% 7.60E+05 1500 kW with 1500 kW I/O Cabinet 96.4% 3.58E+06 99.0% 9.12E+05 Type (480V UPS system) Double conversion eConversionLoad rate 25% 50% 75% 100% Proportion of time at specified load 0.25 0.5 0.25 0 #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System Detailed results, including all the optional indicators mentioned in PCRed4, and the split of the Use Phase (B1 to B7), are available in the LCA report and on demand in a digital format - Country Customer Care Center - http://www.schneider-electric.com/contact kg CO2 eq kg CO2 eq kg CO2 eq kg CO2 eq kg CFC-11 eq mol H+ eq kg (PO4)³⁻eq kg N eq mol N eq kg COVNM eq kg Sb eq MJ m3 eq Additional indicators for the French regulation are available as well MJ MJ MJ MJ MJ kg MJ MJ m³ Contribution to use of non renewable secondary fuels Contribution to net use of freshwater 0.00E+00 2.56E+03 3.77E+02 1.22E+00 1.76E+00 1.15E+03 1.03E+03 -6.12E+03 0.00E+00 0* 0* 0* 0* Contribution to total use of renewable primary energy resources 6.88E+06 2.29E+04 0* 0* 6.85E+06 0* 0* -9.45E+03 3.68E+07 7.30E+05 1.26E+04 0* 3.57E+07 3.52E+05 -8.62E+06 0.00E+00 0.00E+00 0* 0* 0* 0* 0.00E+00 1.27E+00 1.27E+00 0* 0* 0* 0* Contribution to use of secondary material Contribution to total use of non renewable secondary fuels 3.17E+03 -1.91E+05 Contribution to use of renewable primary energy resources used as raw material 3.89E+03 3.89E+03 0* 0* 0* 0* -7.67E+03 Contribution to use of renewable primary energy excluding renewable primary energy used as raw material 6.88E+06 1.90E+04 0* 0* 6.85E+06 Contribution to use of non renewable primary energy resources used as raw material 1.19E+04 1.19E+04 0* 0* 0* 3.17E+03 -1.99E+05 Contribution to use of non renewable primary energy excluding non renewable primary energy used as raw material 3.68E+07 7.18E+05 1.26E+04 0* 3.57E+07 3.52E+05 -8.61E+06 Inventory flows Indicators Galaxy VX UPS System - GVX1250K1250NHS Inventory flows Unit Total Manufact. Distribution Installation Contribution to water use 1.06E+05 1.62E+04 5.26E+01 7.58E+01 4.96E+04 Use End of Life Benefits [A1 - A3] [A4] [A5] [B1 - B7] [C1 - C4] [D] 1.26E-01 -1.07E+02 Contribution to resource use, fossils 3.68E+07 7.30E+05 1.26E+04 0* 3.57E+07 3.52E+05 -8.62E+06 Contribution to resource use, minerals and metals 7.93E+00 7.70E+00 0* 0* 1.02E-01 3.99E+04 -2.63E+05 Contribution to eutrophication marine 1.01E+03 9.22E+01 2.07E+00 1.66E-01 9.08E+02 7.38E+00 -2.70E+02 Contribution to eutrophication, freshwater 8.49E+00 1.77E-01 0* 0* 2.19E-03 3.84E+00 6.43E+01 -3.10E+03 Contribution to photochemical ozone formation - human health 3.26E+03 3.15E+02 7.36E+00 4.29E-01 2.92E+03 1.94E+01 -1.20E+03 Contribution to eutrophication, terrestrial 1.49E+04 1.18E+03 2.25E+01 0* 1.36E+04 1.08E-04 -7.02E-02 Contribution to acidification 8.89E+03 8.50E+02 4.51E+00 0* 8.00E+03 3.55E+01 -5.07E+03 Contribution to ozone depletion 1.99E-02 1.29E-02 9.16E-04 8.90E-06 5.99E-03 4.48E+00 -9.84E-01 Contribution to climate change-fossil 1.50E+06 9.24E+04 1.04E+03 2.89E+02 1.40E+06 6.12E+03 -4.38E+05 Contribution to climate change 1.50E+06 9.31E+04 1.04E+03 2.18E+02 1.40E+06 1.31E+02 -7.38E+03 Contribution to climate change-land use and land use change 2.27E-03 5.00E-05 0* 1.20E-04 0* 2.10E-03 0.00E+00 Contribution to climate change-biogenic 2.60E+03 6.69E+02 0* 0* 1.87E+03 Impact indicators Unit Total Manufacturing Distribution Installation Use End of Life Benefits [A1 - A3] [A4] [A5] [B1 - B7] [C1 - C4] [D] 6.25E+03 -4.46E+05 Mandatory Indicators Galaxy VX UPS System - GVX1250K1250NHS *Net benefits and loads beyond the system boundaries stage (module D): potential for reuse, recovery and/or recycling, expressed as net benefits and impacts. #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System kg kg kg kg kg kg MJ de C kg de C Referent product 500 625 750 800 1000 1100 1250 500 750 1000 1250 1500 1 1 1 1 1 1 1 1 1 1 1 2 3 3 4 4 5 5 2 3 4 5 6 1920 2480 2480 3040 3040 3600 3600 2180 2740 3300 3860 4420 6.37E+05 8.00E+05 9.48E+05 9.86E+05 1.20E+06 1.31E+06 1.50E+06 5.42E+05 8.46E+05 1.17E+06 1.41E+06 1.68E+06 8.86E-03 1.15E-02 1.21E-02 1.42E-02 1.52E-02 1.76E-02 1.99E-02 9.37E-03 1.26E-02 1.59E-02 1.89E-02 2.21E-02 3.79E+03 4.76E+03 5.61E+03 5.87E+03 7.12E+03 7.76E+03 8.89E+03 3.26E+03 5.05E+03 6.93E+03 8.34E+03 9.97E+03 3.74E+00 4.48E+00 5.23E+00 5.96E+00 6.56E+00 7.48E+00 8.49E+00 3.78E+00 5.25E+00 6.76E+00 8.05E+00 9.44E+00 4.30E+02 5.12E+02 6.68E+02 8.09E+02 8.83E+02 1.01E+03 3.71E+02 5.74E+02 7.88E+02 9.49E+02 1.13E+03 6.35E+03 7.98E+03 9.42E+03 9.84E+03 1.20E+04 1.30E+04 1.49E+04 5.44E+03 8.45E+03 1.16E+04 1.40E+04 1.67E+04 1.39E+03 1.75E+03 2.05E+03 2.15E+03 2.61E+03 2.85E+03 3.26E+03 1.20E+03 1.85E+03 2.54E+03 3.06E+03 3.66E+03 3.61E+00 4.75E+00 4.76E+00 5.90E+00 5.91E+00 7.05E+00 7.93E+00 4.14E+00 5.29E+00 6.44E+00 7.59E+00 8.74E+00 1.85E+07 2.32E+07 2.77E+07 2.86E+07 3.52E+07 3.81E+07 3.68E+07 1.55E+07 2.44E+07 3.39E+07 4.09E+07 4.91E+07 4.66E+04 6.06E+04 6.52E+04 7.42E+04 8.19E+04 9.33E+04 1.06E+05 4.68E+04 6.52E+04 8.42E+04 1.00E+05 1.18E+05 2.29E+05 3.36E+05 3.66E+05 4.05E+04 4.51E+04 5.28E+05 4.79E+05 5.26E+05 1.83E+05 2.72E+05 3.55E+05 4.04E+05 4.80E+05 500 625 750 800 1000 1100 1250 500 750 1000 1250 1500 1 1 1 1 1 1 1 1 1 1 1 1 2 3 3 4 4 5 5 2 3 4 5 6 1920 2480 2480 3040 3040 3600 3600 2180 2740 3300 3860 4420 6.09E+05 7.18E+05 8.72E+05 9.27E+05 1.10E+06 1.19E+06 1.35E+06 5.57E+05 8.03E+05 1.05E+06 1.29E+06 1.58E+06 8.74E-03 1.12E-02 1.18E-02 1.40E-02 1.47E-02 1.71E-02 1.78E-02 9.44E-03 1.24E-02 1.55E-02 1.84E-02 2.16E-02 3.62E+03 4.29E+03 5.17E+03 5.53E+03 6.54E+03 7.07E+03 7.99E+03 3.35E+03 4.80E+03 6.28E+03 7.67E+03 9.37E+03 3.66E+00 4.60E+00 5.02E+00 5.80E+00 6.29E+00 7.15E+00 7.59E+00 3.82E+00 5.13E+00 6.45E+00 7.73E+00 9.15E+00 4.12E+02 4.88E+02 5.88E+02 6.29E+02 7.44E+02 8.03E+02 9.09E+02 3.81E+02 5.46E+02 7.13E+02 8.72E+02 1.06E+03 6.07E+03 7.18E+03 8.68E+03 9.26E+03 1.10E+04 1.18E+04 1.34E+04 5.58E+03 8.03E+03 1.05E+04 1.29E+04 1.57E+04 1.33E+03 1.58E+03 1.90E+03 2.03E+03 2.42E+03 2.40E+03 2.59E+03 2.93E+03 1.23E+03 1.76E+03 2.30E+03 2.81E+03 3.43E+03 Contribution to hazardous waste disposed Contribution to radioactive waste disposed Contribution to non hazardous waste disposed 0* 0.00E+00 * represents less than 0.01% of the total life cycle of the reference flow Life cycle assessment performed with EIME version v5.9.4, database version 2022-01 in compliance with ISO14044. Detailed results, including all the optional indicators mentioned in PCRed4, and the split of the Use Phase (B1 to B7), are available in the LCA report and on demand in a digital format - Country Customer Care Center - http://www.schneider-electric.com/contact ** Net benefits and loads beyond the system boundaries stage (module D): potential for reuse, recovery and/or recycling, expressed as net benefits and impacts. Not accounted in the Total. Environmental indicators- 'Total' of Life Cycle Phases (UPS in Double conversion mode) Contribution to climate change (kg CO2 eq) 480V UPS system Galaxy VX UPS (kVA) with 1250 kW I/O Cabinet Galaxy VX UPS (kVA) with 1500 kW I/O Cabinet Product type Product information I/O Cabinet Power Cabinets (250 kW/3U) Weight with Packaging (kg) Compulsory environmental indicators - 'Total' of Life Cycle Phases (UPS in Double conversion mode) Contribution to materials for energy recovery 4.30E-07 4.30E-07 0* 0* 0* 0.00E+00 Please note that the values given above are only valid within the context specified and cannot be used directly to draw up the environmental assessment of an installation. Extrapolated data 400V UPS system Galaxy VX UPS (kVA) with 1250 kW I/O Cabinet Galaxy VX UPS (kVA) with 1500 kW I/O Cabinet Product type Product information I/O Cabinet Power Cabinets (250 kW/3U) Weight with Packaging (kg) 0* 0.00E+00 Contribution to biogenic carbon content of the product 0.00E+00 0* 0* 0* 0.00E+00 Contribution to exported energy 9.26E+01 8.71E+00 0* 8.39E+01 0* Contribution to biogenic carbon content of the associated packaging 0.00E+00 0* 0* 0* 0* 0.00E+00 0* 0* -2.72E+02 Contribution to components for reuse 0.00E+00 0* 0* 0* 0* 0.00E+00 8.72E+01 4.47E+01 2.06E-01 4.74E-02 4.22E+01 3.11E-02 2.66E+03 0.00E+00Contribution to materials for recycling 2.78E+03 2.87E+00 0* 1.18E+02 0* -8.73E+06 2.33E+05 3.07E+04 0* 4.30E+02 2.02E+05 1.86E+02 -4.45E+05 3.04E+05 2.75E+05 0* 0* 2.62E+04 3.11E+03 Contribution to climate change (kg CO2 eq) Contribution to Ozone depletion (kg CFC11 eq) Contribution to Acidification (mol H+ eq) Contribution to eutrophication, freshwater (kg PO43- eq) Contribution to eutrophication marine (kg N eq) Contribution to eutrophication, terrestrial (mol N eq) Contribution to photochemical ozone formation - human health (kg COVNM eq) Contribution to resource use, minerals and metals (kgSbeq) Total use of primary energy (MJ) Contribution to water use (m3 eq) Compulsory environmental indicators - 'Total' of Life Cycle Phases (UPS in Double conversion mode) Contribution to climate change (kg CO2 eq) Contribution to Ozone depletion (kg CFC11 eq) Contribution to Acidification (mol H+ eq) Contribution to eutrophication, freshwater (kg PO43- eq) Contribution to eutrophication marine (kg N eq) Contribution to eutrophication, terrestrial (mol N eq) Contribution to photochemical ozone formation - human health (kg COVNM eq) #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System 3.61E+00 4.74E+00 4.76E+00 5.89E+00 5.90E+00 7.04E+00 7.05E+00 4.14E+00 5.29E+00 6.44E+00 7.58E+00 8.74E+00 1.76E+07 2.07E+07 2.54E+07 2.68E+07 3.21E+07 3.44E+07 3.93E+07 1.59E+07 2.31E+07 3.05E+07 3.74E+07 4.59E+07 4.56E+04 5.71E+04 6.25E+04 7.42E+04 7.83E+04 8.90E+04 9.47E+04 4.73E+04 6.37E+04 8.02E+04 9.62E+04 1.14E+05 2.83E+05 3.36E+05 3.66E+05 4.01E+05 4.19E+05 4.83E+05 5.20E+05 1.83E+05 2.72E+05 3.55E+05 4.05E+05 4.81E+05 Internal External 5 years 2024/4/23 CS 30323 F- 92500 Rueil Malmaison Cedex RCS Nanterre 954 503 439 Capital social 896 313 776 € www.se.com Published by Schneider Electric Schneider Electric Industries SAS Country Customer Care Center http://www.schneider-electric.com/contact 35, rue Joseph Monier ©2023 - Schneider Electric – All rights reserved Independent verification of the declaration and data, in compliance with ISO 14025 : 2010 X The PCR review was conducted by a panel of experts chaired by Julie ORGELET (DDemain) PEP are compliant with XP C08-100-1 :2016 or EN 50693:2019 The elements of the present PEP cannot be compared with elements from another program. Document in compliance with ISO 14025 : 2010 « Environmental labels and declarations. Type III environmental declarations » Date of issue 2024/4/23 Information and reference documents Registration number : SCHN-01185-V01.01-EN Drafting rules PEP-PCR-ed4-2021 09 06 Verifier accreditation N° VH08 Supplemented by www.pep-ecopassport.org Validity period PSR-0010-ed1.1-2015 10 16 Environmental indicators- 'Total' of Life Cycle Phases (UPS in eConversion mode) Contribution to climate change (kg CO2 eq) Other Additional information Operating the Galaxy VX in eConversion mode results in significantly reduced environmental impact, in particular Carbon emissions (up to 65% reduction) compared to operation in Double Conversion mode. This is mainly due to an improved energy efficiency in eConversion of 98.6% (average) compared to an efficiency of 95.8% (average) in Double Conversion mode. For details about eConversion, consult the Schneider-Electric eConversion page: https://www.se.com/ww/en/work/products/product-launch/econversion-high-efficiency-ups- mode/ Compulsory environmental indicators - 'Total' of Life Cycle Phases (UPS in Double conversion mode) Contribution to resource use, minerals and metals (kgSbeq) Total use of primary energy (MJ) Contribution to water use (m3 eq) #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System Reply 12:32 PM (7 minutes ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: 08b931f4-a9b5-41cf-9f4a-a8d96f70e17e7 Bill of Material Build No Reference Description Quantity 1 EALBTP23 licence, Ecostruxure Automation Expert, standard engineering buildtime, v23 1 2 EALBFP23 license, Ecostruxure Automation Expert, professional engineering, buildtime, v23 1 Run No Reference Description Quantity 3 EALDSP license, EcoStruxure Automation Expert, standard device runtime, add on, v23 6 4 EALDHP license, EcoStruxure Automation Expert, high availability option, runtime, add on, v23 7 5 EALADP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for ATV dPac 1 6 EALAMP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M251, M262 dPAC 2 7 EALASP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M580 dPAC 1 8 EALALP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M580 dPAC with extensions 1 Run Add-on No Reference Description Quantity 9 EALH1P license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony ST6 1 10 EALH2P license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony iPC 1 Service plan No Reference Description Quantity 11 ECAUTESEAE Service plan for EcoStruxure Automation Expert - Essential 294 ... Software license configurator 1. Software selectionDone License selectorDone 3. Finalize and shareDone Bill of materials My Configuration Verification No Reference Description Quantity 1 CEGVER01AN license, EcoStruxure Control Engineering, verification, basic, node locked, 1 shot 1 Documentation No Reference Description Quantity 2 CEGDOC01AN license, EcoStruxure Control Engineering, documentation, basic, node locked, 1 shot 1 Software license configurator 1. Software selectionDone License selectorDone Service plansDone 4. Finalize and shareDone Bill of materials My Configuration Regular No Reference Description Quantity 1 CEXSPUCZSSPZZZ Control Expert S single e-licence 1 2 CEXSPMCZXTPAZZ License, EcoStruxure Control Expert, Topology Manager & M580 safety add-on for XL, team floating (10 users), digital 1 Service plan No Reference Description Service plan size 3 ECAUTESECE Service plan for EcoStruxure Control Expert - Essential 283 Your configuration has been saved! Copy the configuration ID to your clipboard Send by email Add to my project Export (1) Export the bill of material in XLS .xls Documentation (2) Product Data Sheet .zip Catalog Configuration Name : My Configuration Configuration ID : f9d295b2-90b2-4164-b665-04551a1f2f54 Date : Sun Mar 09 10:52:15 UTC 2025 Operation Server No Reference Description Quantity 1 EUSOPECZZSPEZZ SW PE OPER SERVER LIC 6 Operation Client No Reference Description Quantity 2 EUSLCCCZZSPEZZ SW PE CTRL CLIENT LIC 1 3 EUSVRCCZZSPEZZ SW PE VIEW CLIENT LIC 1 4 EUSLRCCZZSPEZZ SW PE RED VIEW CLIENT LIC 1 Service plan No Reference Description Quantity 6 ECAUTESEPE Service plan for EPE - Essential 608 Product Selector Tool This tool is designed to assist you through the product selection process. Try our Product Selector Content Training Installed Base Programs Overview Product Configurators PLC Your products have been added to a New Project/BOM View BOM Select your location Tshingombe fiston Software license configurator 1. Software selectionDone License selectorDone Service plansDone 4. Finalize and shareDone Bill of materials Perpetual My Configuration Design & Build No Reference Description Quantity 1 EALBTP23 licence, Ecostruxure Automation Expert, standard engineering buildtime, v23 1 2 EALBFP23 license, Ecostruxure Automation Expert, professional engineering, buildtime, v23 1 Operate & Maintain No Reference Description Quantity 3 EALDSP license, EcoStruxure Automation Expert, standard device runtime, add on, v23 6 4 EALDHP license, EcoStruxure Automation Expert, high availability option, runtime, add on, v23 7 5 EALADP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for ATV dPac 1 6 EALAMP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M251, M262 dPAC 2 7 EALASP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M580 dPAC 1 8 EALALP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M580 dPAC with extensions 1 Run Add-on No Reference Description Quantity 9 EALH1P license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony ST6 1 10 EALH2P license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony iPC 1 Service plan No Reference Description Quantity Service plan size 11 ECAUTESEAE Service plan for EcoStruxure Automation Expert - Essential 294 Your configuration has been saved! Copy the configuration ID to your clipboard Send by email Add to my project Export (1) Export the bill of material in XLS .xls Documentation (2) Product Data Sheet .zip Catalog pdf Feedback Back Go to start page Back Go to start page mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric mySchneider Design & Build;;; No;Reference;Description;Quantity 1;EALBTP23;licence Ecostruxure Automation Expert standard engineering buildtime v23;1 2;EALBFP23;license Ecostruxure Automation Expert professional engineering buildtime v23;1 Operate & Maintain;;; No;Reference;Description;Quantity 3;EALDSP;license EcoStruxure Automation Expert standard device runtime add on v23;6 4;EALDHP;license EcoStruxure Automation Expert high availability option runtime add on v23;7 5;EALADP;license EcoStruxure Automation Expert run time application permanent 1 user for ATV dPac;1 6;EALAMP;license EcoStruxure Automation Expert run time application permanent 1 user for M251 M262 dPAC;2 7;EALASP;license EcoStruxure Automation Expert run time application permanent 1 user for M580 dPAC;1 8;EALALP;license EcoStruxure Automation Expert run time application permanent 1 user for M580 dPAC with extensions;1 Run Add-on;;; No;Reference;Description;Quantity 9;EALH1P;license EcoStruxure Automation Expert run time HMI permanent 1 user for Harmony ST6;1 10;EALH2P;license EcoStruxure Automation Expert run time HMI permanent 1 user for Harmony iPC;1 Service plan;;; No;Reference;Description;Quantity 11;ECAUTESEAE;Service plan for EcoStruxure Automation Expert - Essential;294 Your configuration has been saved! EcoStruxure™ Motor Control Configurator 1. Voltage440 V 4. Motor details5.5-55 kW AdjustDone OptionsDone 5. Save & ShareDone My Configuration Technology: direct starter Supply Voltage: 440 V Standard: IEC (kW) Motor power: 55 kW Coordination type 1 Number of product: 2 products Range: 664 Starter Type: Direct Online PLC Control: no Breaking performance Iq: 50 kA Coil Type: Standard Coil voltage: 230 V AC - 50/60 Hz Power terminal connection: Screw Clamp Motor efficiency class: IE3 Breaker GV4P115N Motor circuit breaker, TeSys GV4, 3P, 115A, Icu 50kA, thermal magnetic, Everlink terminals Accessories GV4AE11 Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC GV4AE11 Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC Contactor LC1D115P7 Contactor, TeSys Deca, 3P(3NO), AC-3/AC-3e, Show options (1) Contactor LC1D115P7 Contactor, TeSys Deca, 3P(3NO), AC-3/AC-3e, Show options (1) Your configuration has been saved! Copy the configuration ID to your clipboard dc5b40a4-bb0a-4e45-b277-b7fa55863d6a Please find a summary of Energy Savings delivered for Drive instead of a fixed speed solution This data is to be considered with assemption Export (2) Print Export Bill of Material (.xls) .xls Documentation (6) Product Data Sheet Bill of Material - My Configuration - 6b546e9d-8a2e-424f-af3c-939ea886fdcd - Schneider Electric Inbox No reply 12:45 PM (14 minutes ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: 6b546e9d-8a2e-424f-af3c-939ea886fdcd Bill of Material Verification No Reference Description Quantity 1 CEGVER01AN license, EcoStruxure Control Engineering, verification, basic, node locked, 1 shot 1 Documentation No Reference Description Quantity 2 CEGDOC01AN license, EcoStruxure Control Engineering, documentation, basic, node locked, 1 shot 1 Service plan No Reference Description Quantity ... [Message clipped] View entire message Bill of Material - My Configuration - 577e9790-a49e-4c0c-9307-f56f18a5ab60 - Schneider Electric Inbox No reply 12:50 PM (10 minutes ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: 577e9790-a49e-4c0c-9307-f56f18a5ab60 Bill of Material Regular No Reference Description Quantity 1 CEXSPUCZSSPAZZ License, EcoStruxure Control Expert, service pack base, small S, 1 user, node locked, digital license 1 2 CEXSPMCZXTPAZZ License, EcoStruxure Control Expert, with Topology Manager and M580 safety, for XL, node locked, 10 users, digital 1 Service plan No Reference Description Quantity 3 ECAUTESECE Service plan for EcoStruxure Control Expert - Essential 283 ... [Message clipped] View entire message Bill of Material - My Configuration - f9d295b2-90b2-4164-b665-04551a1f2f54 - Schneider Electric Inbox No reply 12:54 PM (6 minutes ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: f9d295b2-90b2-4164-b665-04551a1f2f54 Bill of Material Operation Server No Reference Description Quantity 1 EUSOPECZZSPEZZ SW PE OPER SERVER LIC 6 Operation Client No Reference Description Quantity 2 EUSLCCCZZSPEZZ SW PE CTRL CLIENT LIC 1 3 EUSVRCCZZSPEZZ SW PE VIEW CLIENT LIC 1 4 EUSLRCCZZSPEZZ SW PE RED CTRL CLIENT LIC 1 5 EUSVRCCZZSPEZZ SW PE VIEW CLIENT LIC 1 Service plan No Reference Description Quantity 6 ECAUTESEPE Service plan for EPE - Essential 608 ... Bill of Material - My Configuration - dc5b40a4-bb0a-4e45-b277-b7fa55863d6a - Schneider Electric Inbox tshingombe tshitadi 12:58 PM (2 minutes ago) to me Dear tshingombe tshitadi, Please find your configuration created from: EcoStruxureTM Motor Control Configurator Configuration link: My Configuration Your configuration ID: dc5b40a4-bb0a-4e45-b277-b7fa55863d6a Motor starter parameters selected Technology: Direct Start Standard: IEC Supply Voltage: 440 V Motor Power: 55 kW Motor efficiency class: IE3 Breaker breaking performance Iq: 50 kA Contactor Coil voltage: 230 V AC - 50/60 Hz Power terminal connection: Screw Clamp Coil Type: Standard Bill of Material Devices Options Description Quantity: Breaker GV4P115N Motor circuit breaker, TeSys GV4, 3P, 115A, Icu 50kA, thermal magnetic, Everlink terminals 1 GV4AE11 Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC Auxiliary Contact Block > Front Function Sd > 1 NO + 1 NC - SD function 1 GV4AE11 Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC Auxiliary Contact Block > Front Function On/off > 1 NO + 1 NC - OF function 1 Contactor LC1D115P7 Contactor, TeSys Deca, 3P(3NO), AC-3/AC-3e, Front Clip Position 1 > 1 0180 s - 1 NO + 1 NC 1 LX1D8P7 Spareparts 1 Voltage440 V OptionsDone 1. Save & ShareDone My Configuration Technology: soft starter Supply Voltage: 440 V Standard: IEC (kW) Motor power: 132 kW Segment and process: Machine Manufacturing Application: Standard Machines Service duty: Normal duty Coordination type: Coordination type 1 Range: 5745 Communication module: Modbus SL (embedded) Motor Softstarter connection: In line Integrated bypass: yes With trip unit: yes Breaking capacity: 50 kA Coil Type: without coil Breaker C40H31M320 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A Contactor LC1F265 Contactor body,TeSys F,3P(3NO)-AC-3, <=440V 265A without coil Auxiliary contact block, TeSys Deca, 1NC, front mounting, screw clamp terminals Auxiliary contact block, TeSys Deca, 1NO+1NC, front mounting, screw clamp terminals LADN13 Auxiliary contact block, TeSys Deca, 1NO+3NC, front mounting, screw clamp terminals Soft starter ATS22C25Q soft starter for asynchronous motor, Altistart 22, control 230V, 230 to 440V, 75 to 132kW My Configuration ZA Add to My Products Technology: soft starter Supply Voltage: 440 V Standard: IEC (kW) Motor power: 132 kW Segment and process: Machine Manufacturing Application: Standard Machines Service duty: Normal duty Coordination type: Coordination type 1 Range: 5745 Communication module: Modbus SL (embedded) Motor Softstarter connection: In line Integrated bypass: yes With trip unit: yes Breaking capacity: 50 kA Coil Type: without coil Breaker C40H31M320 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A Contactor LC1F265 Contactor body,TeSys F,3P(3NO)-AC-3, Show options (3) Soft starter ATS22C25Q soft starter for asynchronous motor, Altistart 22, control 230V, 230 to 440V, 75 to 132kW Your configuration has been saved! Copy the configuration ID to your clipboard 98d8730c-cef0-4fd3-8fbe-b6f8b3c1d66b Please find a summary of Energy Savings delivered for Drive instead of a fixed speed solution This data is to be considered with assemption Export (2) Print Export Bill of Material (.xls) .xls Documentation (6) Product Data Sheet .zip Variable Speed Drive EcoStruxure™ Motor Control Configurator My Configuration Technology: variable speed drive Supply Voltage: 480 V Standard: IEC (kW) Motor power: 132 kW Segment and process: Machine Manufacturing Application: Standard Machines Service duty: Heavy duty Range: 63124 Communication module: Modbus SL Installation type: wall mounted Protection level: IP21 With trip unit: yes Breaking capacity: 50 kA Coil Type: without coil Breaker C40H31M320 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A Accessories 29452 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type 29452 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type Contactor LC1F265 Contactor body,TeSys F,3P(3NO)-AC-3, Show options (3) Drive ATV930C16N4 variable speed drive, Altivar Process ATV900, ATV930, 160kW, 380 to 480V, with braking unit, IP20 Your configuration has been saved! Copy the configuration ID to your clipboard 96d5a340-770b-4927-bab7-5c538288d832 This data is to be considered with assemption Export (2) Print Export Bill of Material (.xls) .xls Documentation (6) Product Data Sheet .zip CAD files Modicon PLC 1. HomeDone PLC selectionDone Graphical editorDone Power supplyDone AccessoriesSkipped 6. Finalize and shareDone My Configuration Range Pardrive LMC Power supply 24 Vdc Field bus protocols EtherNet/IP; Sercos Bill of materials Add to Favorites Controller + I/O No Reference Description Quantity 1 LMC216CAA10000 Motion controller LMC216 16 axis - Acc kit - Basic 1 2 ABL8WPS24200 Regulated switch power supply, modicon power supply, 3 phases, 380 to 500V AC, 24V, 20A 1 3 GV2ME06 Motor circuit breaker, TeSys Deca, 3P, 1 to 1.6A, thermal magnetic, screw clamp terminals, button control 1 4 ABL8BBU24400 battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 20A, for regulated SMPS 1 5 ABL8BBU24400 battery control module, phaseo ABL7 ABL8, 24V, 40A, for regulated SMPS 1 6 BVS480XDPDR Easy UPS control module, 24V DC-DC, DIN Rail, Industrial, 20A 1 7 XB005XPDR Easy UPS battery module, 24V DC-DC, DIN Rail, Industrial, 4.5Ah 1 Your configuration has been saved! Copy the configuration ID to your clipboard Send by email Add to my project Export (5) Export to EcoStruxure Machine Expert .py Export PNG picture .zip Export the bill of material in XLS .xls Export project in PDF .pdf Export architecture in PDF .pdf Documentation (6) Product Data Sheet .zip CAD .zip Instruction Sheet .zip User guide .zip Certificate .zip Catalog .zip Feedback Bill of Material - My Configuration - 98d8730c-cef0-4fd3-8fbe-b6f8b3c1d66b - Schneider Electric Inbox tshingombe 1:09 PM (12 minutes ago) to me Dear tshingombe, Please find your configuration created from: EcoStruxureTM Motor Control Configurator Configuration link: My Configuration Your configuration ID: 98d8730c-cef0-4fd3-8fbe-b6f8b3c1d66b Motor starter parameters selected Technology: Soft Starter Standard: IEC Supply Voltage: 440 V Motor Power: 132 kW Segment and Process: Machine Manufacturing Application: Standard machines Heavy Duty selection: no Breaker Breaking capacity: 50 kA With trip unit: yes Contactor Coil voltage: n/a Coil Type: without coil Soft Starter Integrated bypass: yes Bill of Material Devices Options Description Quantity: Breaker C40H31M320 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A 1 LV432513 Spareparts 1 Contactor LC1F265 Contactor body,TeSys F,3P(3NO)-AC-3, Right > 1 NO + 1 NC 1 LADN11 Auxiliary contact block, TeSys Deca, 1NO+1NC, front mounting, screw clamp terminals Auxiliary Contact For Standard Environment > Front Clip Position 1 > 1 NO + 1 NC 1 LADN13 Auxiliary contact block, TeSys Deca, 1NO+3NC, front mounting, screw clamp terminals Auxiliary Contact For Standard Environment > Front Clip Position 1 > 3 NC + 1 NO 1 Soft Starter ATS22C25Q soft starter for asynchronous motor, Altistart 22, control 230V, 230 to 440V, 75 to 132kW 1 Bill of Material - My Configuration - 96d5a340-770b-4927-bab7-5c538288d832 - Schneider Electric Inbox tshingombefiston 1:12 PM (9 minutes ago) to me Dear tshingombefiston, Please find your configuration created from: EcoStruxureTM Motor Control Configurator Configuration link: My Configuration Your configuration ID: 96d5a340-770b-4927-bab7-5c538288d832 Motor starter parameters selected Technology: Variable Speed Drive Standard: IEC Supply Voltage: 480 V Motor Power: 132 kW Segment and Process: Machine Manufacturing Application: Standard machines Heavy Duty selection: no Breaker Breaking capacity: 50 kA With trip unit: yes Contactor Coil voltage: n/a Coil Type: without coil Drive Installation type: wall mounted Protection level: IP21 Bill of Material Devices Options Description Quantity: Breaker C40H31M320 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A 1 29452 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type Add-on Auxiliary Contact-low Level > Front Function Sde > SDE function 1 29452 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type Add-on Auxiliary Contact-low Level > Front Function Sd > SD function 1 29452 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type Add-on Auxiliary Contact-low Level > Front Function On/off > ON/OFF 1 LV432513 Spareparts 1 Contactor LC1F265 Contactor body,TeSys F,3P(3NO)-AC-3, Clip On Rail mounting > 127240 V AC 1 LADT0 Time delay auxiliary contact block, TeSys Deca, 1NO+1NC, on delay 0.3s, front, screw clamp terminals Time On Delay > Front Clip Position 1 > 0.13 s - 1 NO + 1 NC 1 LADT2 Time delay contact block,TeSys Deca,1NO+1NC,on-delay 1-30s,front Time On Delay > Front Clip Position 1 > 0 130 s - 1 NO + 1 NC 1 LA5FH431 Spareparts 1 Drive ATV930C16N4 variable speed drive, Altivar Process ATV900, ATV930, 160kW, 380 to 480V, with braking unit, IP20 1 Bill of Material - My Configuration - 36455ef8-f6c2-460a-91c3-15d69cf9452f - Schneider Electric Inbox No reply 1:16 PM (6 minutes ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: 36455ef8-f6c2-460a-91c3-15d69cf9452f Bill of Material Bom level Position Reference Description Quantity My Configuration 1 LMC216CAA10000 Motion controller LMC216 16 axis - Acc kit - Basic 1 My Configuration 2 ABL8WPS24200 Regulated switch power supply, modicon power supply, 3 phases, 380 to 500V AC, 24V, 20A 1 My Configuration 3 GV2ME06 Motor circuit breaker, TeSys Deca, 3P, 1 to 1.6A, thermal magnetic, screw clamp terminals, button control 1 My Configuration 4 ABL8BBU24200 battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 20A, for regulated SMPS 1 My Configuration 5 ABL8BBU24400 battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 40A, for regulated SMPS 1 My Configuration 6 BVS480XDPDR Easy UPS control module, 24V DC-DC, DIN Rail, Industrial, 20A 1 My Configuration 7 XB005XPDR Easy UPS battery module, 24V DC-DC, DIN Rail, Industrial, 4.5Ah 1 ... Bill of Material - My Configuration - 9988cbd9-4fe8-473c-927f-c3473aaf67af - Schneider Electric Inbox No reply 1:21 PM (1 minute ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: 9988cbd9-4fe8-473c-927f-c3473aaf67af Bill of Material Bom level Position Reference Description Quantity My Configuration 1 TM171ODM22R Controller, Modicon M171/M172/M173, optimized display 22 IO, Modbus 1 My Configuration 2 TM171ACB4OI1M Modicon M171 Optimized LV Connector 1m cable 1 My Configuration 3 TM171ACB4OAO1M Modicon M171 Optimized AO Connector 1m cable 1 My Configuration 4 TM171ACB4OAO2M Modicon M171 Optimized AO Connector 2m cable 1 My Configuration 5 TM171DLED Modicon M171 Optimized Display LED 1 My Configuration 6 TM171DLCD2U Modicon M171 Optimized Display LCD 1 My Configuration 7 TM171DWAL2U Modicon M171 Optimized Wall thermostat without backlight 1 My Configuration 8 TM171STNTCRN52015 NTC 1,5m IP68 5x20 -50+110°C Grey 1 My Configuration 9 TM171STNTCRN520IP NTC 1,5m IP68 5x20 -50+110°C Grey 1 My Configuration 10 TM171STNTCRN52030 NTC 3,0m IP68 5x20 -50+110°C Grey 1 My Configuration 11 TM171VEVA2 EEV Driver, Actuator 1 My Configuration 12 TM171VEVD4 EEV Driver, Autonomous & Hardwired 1 My Configuration 13 TM171VEVM4 EEV Driver, Autonomous & Modbus 1 ... [Message clipped] View entire message You can now access the Industrial Automation and Control catalogs, in both English and French > Consult digital automation catalogs at Digi-Cat Online Select your training > Find the right Training for your needs on our Global website > Locate the training center with the selector tool, using this link Quick access to product information Get technical information about your product Each commercial reference presented in a catalog contains a hyperlink. Click on it to obtain the technical information of the product: – Characteristics, Dimensions and drawings, Mounting and clearance, Connections and schemas, Performance curves – Product image, Instruction sheet, User guide, Product certifications, End of life manual • Up-to-date catalogs • Embedded product selectors, 360° pictures • Optimized search by commercial references General contents EcoStruxure™ Automation Expert b General presentation v EcoStruxure Automation Expert...page 2 v Feature overview ....page 3 b Presentation v Software - EcoStruxure Automation Expert engineering .... page 4 - EcoStruxure Automation Expert - HMI .... page 5 - EcoStruxure Automation Expert - Archive .... page 5 - EcoStruxure Automation Expert - AVEVA System Platform integration.......................page 5 - EcoStruxure Automation Expert - Libraries .... page 5 - System requirements............................page 9 v Hardware - Software dPAC .... page 10 - Edge Controller..page 11 - Altivar and Modicon dPAC ....page 11 - Selection Guide ....page 14 - Architecture ....page 17 v Licenses - EcoStruxure Automation Expert – Perpetual licensing .... page 20 - EcoStruxure Automation Expert – Subscription-based licensing .... page 21 - EcoStruxure Automation Expert Licensing – Architecture .... page 21 b Compatibility v List of X80 hardware compatible with Modicon M580 dPAC .... page 28 v List of TM3 hardware compatible with ModiconM251 dPAC and M262 dPAC .... page 30 v Altivar hardware and Altivar ATV dPAC .... page 31 b References v Modicon M580 dPAC .... page 32 v Modicon M251 dPAC .... page 36 v Modicon M262 dPAC .... page 37 v Altivar ATV dPAC .... page 38 b Services.. page 40 b Product reference index...page 42 1 2 EcoStruxure™ Automation Expert Industrial automation systems EcoStruxure Automation Expert General presentation Libraries Operator Station Automation Expert HMI Runtime Modicon dPAC Engineering Automation Expert Communications X80 TM3 I/O & Enc M580 dPAC M2xx dPAC ATV dPAC Soft dPAC Linux/HA Soft dPAC Windows Automation ExpertHistorization Automation Expert Archive Control Room AVEVA System Platform CRD + X80 EcoStruxure Automation Expert consists of a suite of integrated hardware and software solutions: > EcoStruxure Automation Expert build time - engineering, monitoring, and management environment > Distributed Programmable Automation Controller (dPAC) platforms with the Universalautomation.org Shared Source Runtime engine: b ATV dPAC for Altivar b Modicon M251 dPAC/TM3 I/O b Modicon M262 dPAC/X80 I/O > Plus, innovative new software-based controllers: b Soft dPAC for Linux™, for standalone and high availability configurations b Soft dPAC for Windows™ , for standalone configurations > EcoStruxure Automation Expert - HMI, a fully integrated, object-oriented industrial visualization solution > EcoStruxure Automation Expert - Archive, a centralized solution for the historization of process data, alarms, and trends > Schneider Electric Libraries, a comprehensive set of hardware-independent libraries, ranging from basic functions up to segment solutions > Asset Link for Bulk Engineering to extract data from engineering tools for automated application generation > Asset Link for AVEVA OMI to create application objects (AppObjects) in the AVEVA System Platform in an automated workflow Note: Universalautomation.org is an independent, non-for-profit association managing the implementation of an industrial automation shared source runtime execution engine, based on the IEC 61499 standard that is a object-oriented further development of IEC 61131 with the cyclical execution model of IEC 61131 replaced by an event-based model. This new level of shared technology provides the basis for an ecosystem of portable, interoperable, "plug and produce" solutions and creates an entirely new category within industrial automation. EcoStruxure Automation Expert is a software-defined industrial automation system, a new category of industrial automation that leverages innovative technology to enable industrial operators to realize a step-change improvement over traditional process control systems and deliver significant advancement in productivity, quality, flexibility, and security throughout the entire lifecycle of industrial assets. 3 Feature overview EcoStruxure Automation Expert represents a new approach to designing, building, operating, and maintaining industrial automation systems that offers a unique technology mix to define a new category of integrated automation systems. Complexity mastered Systems, devices, services, and assets are natively represented as ready-to-use software objects called composite automation types (CATs) that encapsulate internal behaviour and simplify functional interfaces. An object-oriented approach promotes code reuse, standardization on best practice, and helps manage complexity while providing the fundamental building blocks for the creation of state-of-the-art cyber-physical systems. CAT objects follow a type/instance relation and can be combined to create new objects that encapsulate: b Control logic b HMI/SCADA visualization b I/O and device communications b Simulation and test rigging b Documentation Decoupling the application from hardware EcoStruxure Automation Expert addresses full automation system engineering and extends the best features of classic PLC and DCS control approaches to a new generation of automation system that completely decouples the application design from runtime deployment, enabling automation professionals to focus on these tasks independently in their project lifecycle. Applications are portable, reusable, and interoperable across runtime platforms, meaning deployment decisions are made just in time and on the fly, enabling exceptional system agility. Efficient engineering EcoStruxure Automation Expert build time provides a single, modular engineering environment for all tasks for engineering, monitoring, and managing the complete automation system including hardware and software, control, and visualization. It automates low value engineering and integration tasks, reducing engineering effort and sources of error by Asset Link to perform digital engineering. Complex functions can be encapsulated into manageable objects, enabling non-technical users to understand and manage complex systems. Cross communications are transparent and implicit regardless of physical location, requiring zero engineering consideration. Common runtime environment Through the implementation of the shared source Runtime engine provided by universalautomation.org across hardware and software platforms, exceptional re-usability, scalability, and architectural flexibility are now available. Application portability provides cost savings through the decoupling of the lifecycles of software and hardware systems. Simple system orchestration Software Defined System The engineering environment of EcoStruxure Automation Expert was designed with the complete lifecycle of an automation system in mind, with functions to facilitate management and monitoring of multiple assets and devices at scale. With a single user environment covering the entire system scope including third-party devices, orchestration of complex, heterogeneous systems becomes simpler. Native IT integration Modern automation systems generate increased value when coupled with business information and hence wider IT ecosystems. EcoStruxure Automation Expert provides an expandable platform for Industry 4.0 solutions with support for high-level programming, modular systems design, and open standards. Thanks to event-driven execution and object-oriented design, EcoStruxure Automation Expert applies to IT programming language standards. Cybersecurity EcoStruxure Automation Expert includes robust support for cybersecurity including centralized user management and secure communications. User and device credentials are managed by the EcoStruxure Automation Expert build time environment, and secure communications are available between controllers, HMI, SCADA, and third-party devices. Industrial automation systems EcoStruxure Automation Expert General presentation (continued) 4 EcoStruxure Automation Expert Software The EcoStruxure Automation Expert software offer includes: b The EcoStruxure Automation Expert engineering environment, with add-ons for integration of AVEVA Engineering and AVEVA System Platform software b EcoStruxure Automation Expert HMI Runtime b EcoStruxure Automation Expert Archive b Asset-oriented application libraries EcoStruxure Automation Expert engineering EcoStruxure Automation Expert is an asset-based, fully-integrated engineering environment that allows portable, IEC 61499-standard-based automation systems to be managed within a single environment. EcoStruxure Automation Expert provides the capability to: b Design and manage asset-based applications using object libraries based on multifaceted models (asset logic, operating modes, HMI symbols and faceplates (including alarms and trends), I/O interface, and asset documentation) b Design the process based on asset-oriented objects with single line connections b Create rich process displays to monitor and control the process from the control room or line terminal by dragging and dropping asset-based objects b Manage a single solution independently of the number of controllers and HMI stations b Design the application solution independently of the hardware configuration b Test and simulate the control and HMI for the whole solution b Create and modify procedural automation CATs based on S88 state model with graphical editor b Support multi-user change management through SVN client integration b Design, configure, and manage network and device topologies b Flexibly deploy applications to multiple hardware or software platforms based on a common runtime b Automatically discover and diagnose compatible runtime devices b Automate bulk generation of asset instances from AVEVA Engineering or DEXPI files b Automate bulk generation of asset instances for AVEVA System Platform b Embedded AVEVA industrial graphic editor in EcoStruxure Automation Expert build time to create new AVEVA industrial graphics or to reuse graphics from existing applications b Secure the automation system by managing authentication with encrypted communication and security certificates at solution and devices level EcoStruxure Automation Expert V24.0 build time Industrial automation systems EcoStruxure Automation Expert Software Presentation 5 EcoStruxure Automation Expert Software EcoStruxure Automation Expert – HMI EcoStruxure Automation Expert HMI is a tightly integrated human-machine interface designed for EcoStruxure Automation Expert. Its features include: b Compatibility with WindowsTM OS/LinuxTM OS hardware b Controller Harmony ST6 b Seamless management of controller and HMI communication b Support for single/multi operator stations with cloning b User management for access control b Multi-language application b Monitoring of runtime connections The EcoStruxure Automation Expert HMI Client for WindowTM/LinuxTM operating system can be installed on various hardware such as Workstations, Industrial PCs, and Edge Boxes, provided they meet the minimum system requirements. It ensures high-performance, seamless management of controller and HMI communication. Furthermore, the EcoStruxure Automation Expert HMI Client for Harmony ST6 is compatible with HMIST6200, HMIST6400, HMIST6500, HMIST6600, HMIST6700, HMISTM6400, and HMISTM6200 touch panel screens. It offers seamless management of controller and automatic HMI communication, particularly ideal for a small number of assets. EcoStruxure Automation Expert – Archive EcoStruxure Automation Expert Archive operates as a highly integrated local data historian, providing minimal engineering effort historization and retrieval of live process data, alarms, and events within EcoStruxure Automation Expert HMI and the ability to integrate with larger enterprise data storage systems by Structured Query Language (SQL). It is compatible with Windows 10, Windows 11, and Linux operating system. EcoStruxure Automation Expert – AVEVA System Platform integration EcoStruxure Automation Expert includes native support for System Platform - AVEVA's real-time operations control platform for supervisory, HMI, SCADA, and IIoT applications. EcoStruxure Automation Expert is capable of auto-generating OPC UA-based secure communications between platforms and generate AVEVA System Platform-compatible graphics for clean integration. Furthermore, it now embeds the AVEVA Industrial Graphics editor so that users no longer

need to move from EcoStruxure Automation Expert buildtime to AVEVA buildtime, providing unprecedented integration. Automation Expert version Library compatible version Platform version for Asset Link Version for Asset Link and AVEVA Industrial Graphics V23.0 AVEVA System Platform 2020 R2 SP1 or later No AVEVA Industrial Graphics support V23.1 AVEVA System Platform 2023 AVEVA System Platform 2020 R2 SP1 or later (New Galaxy creation is possible only with Library compatible version)* AVEVA System Platform 2023 or R2 SP1 AVEVA System Platform 2020 R2 SP1 or later (New Galaxy creation is possible only with AVEVA System Platform 2023 R2 SP1)* AVEVA System Platform 2023 or later (New Galaxy creation is possible only with AVEVA System Platform 2023 R2 SP1)* *Only Select Existing Galaxy from the configurator is possible if Library compatible version is not available with the user. Embedded AVEVA industrial graphic editor in EcoStruxure Automation Expert build time Industrial automation systems EcoStruxure Automation Expert Software Presentation (continued) 6 EcoStruxure Automation Expert Software (continued) EcoStruxure Automation Expert – Libraries EcoStruxure Automation Expert includes a set of application libraries with generic process and control modules such as motors / valves and segment-based libraries with equipment modules that include multiple facets – logic, Automation Expert HMI, AVEVA System Platform template, and documentation within a single package to minimize the engineering time. EcoStruxure Automation Expert also includes a hardware library for easier integration of the most common Schneider Electric and Technical Partner's field devices through Modbus TCP / Ethernet IP that provides the mapping, HMI, and documentation to be used in the application. With version 24.0 release, the free libraries included are 0 Field Device Base and common process b Sequence management and Phase Management b Liquid food b Water & Wastewater (including desalination) b Single line power monitoring b Conveying These libraries include HMI objects that are compatible with Windows and Linux Ubuntu native HMI runtime, including the Harmony HMIST6xxx and HMISTM6xxx panels. Additionally, Universal Automation vendors provide specific hardware libraries to deploy EcoStruxure Automation Expert applications to their offer. Industrial automation systems EcoStruxure Automation Expert Software Presentation (continued) With this release the library updates include: b Elementary blocks with easier customization covering basic application functions like alarms, conditions, owners, and signal conditioning that are used by other application CATs – SE.App2Base. b Library of application CATs with easier customization to address common process assets or functions like digital I/O, analog I/O, motors, valves, and flowcontrol. There are multiple layers of each object available which can be used and customized for various application purposes – SE.App2CommonProcess. b Stage management functionality for generic application (State Manager) as well as ISA-88 base application (Phase State Manager) Phase State Manager plus Command Logic Engine (CLE) is used for ISA-88 base application objects. Phase state manager status – SE.App2StateManagement. Example of HWCAT symbol and faceplate on EcoStruxure Automation Expert HMI Example of Application CAT symbol and faceplate on AVEVA OMI Application – Common Process Setpoint, Signal Processing, Motors, Valves, Process Control, Flow Control, Pump Set M580 dPAC CPU, X80 I/O Modules M251 dPAC CPU, TM3 I/O Modules M262 dPAC CPU, TM3 I/O Modules ATV dPAC Soft dPAC I/O Modbus Read/Write registers Field Device Modbus/TCP ATV, ATS, Lexium, PowerMeter Gateways Modbus Gateway, UDP Gateway HARDWARE SPECIALIZED APPLICATION GENERAL APPLICATION Application – Base Deviation Alarm, Limit Alarm, Range of Change Alarm, State Alarm Conditions, Owner Application 2 – Base Deviation Alarm, Limit Alarm, Range of Change Alarm, State Alarm Conditions, Owner Application – Sequence Sequence Step, Sequence Action Application 2 – Common Process Setpoint, Signal Processing, Motors, Valves, Process Control, Flow Control, Pump Set Segment Applications WWW, Single Line Power Monitoring, Conveying, Liquid Food, State Management Application (Phase State Manager) Phase Manager also uses the SE.App2StateManagement state management library. Phase state manager status – SE.App2StateManagement Procedure Procedure Control Tasks SE.AppProcedure Procedure control tasks is used to manage phases based on ISA-88 associated with sequences in coordination with sequence control blocks from SE.AppSequence. It also includes a phase logical interface that accepts commands from external batching interfaces such as AVEVA Batch Management and returns the phase manager status. SE.AppWWW Waste and wastewater This library contains blocks used to monitor and manage control sequences like aeration and dual media filter for Water and Wastewater applications SE.DPAC dPAC hardware controllers Library containing the dPAC device types AVEVA.IndustrialGraphicsLibrary Industrial graphics library Industrial Graphics are vector-based graphics that can be scaled, animated, embedded into application objects, and deployed. The library contains common industrial equipment. You can modify graphics or add graphics to the library by creating new graphics using the Industrial Graphic Editor. SE.EAEPortal AVEVA System Platform Device type The AVEVA System Platform device type is required by Asset Link for establishing communication and creating the application objects automatically in AVEVA System Platform SE.FieldAdvice Field device hardware CATs This library has ready-to-use hardware CATs for motor control, energy management, machine safety, and wind turbine. SE.HwCommon Common hardware CAT functions Library of functions used by the various hardware CAT libraries SE.IoATV Variable speed drive I/O services for ATV dPAC Library of hardware CATs for Altivar I/O (local and modules) used for the Altivar dPAC module hardware configuration 8 Industrial automation systems EcoStruxure Automation Expert Software Presentation (continued) EcoStruxure Automation Expert Software (continued) EcoStruxure Automation Expert – Libraries (continued) EcoStruxure Automation Expert libraries (continued) Library name Short description Extended description SE.IoNet UDP gateway Library of hardware CATs to enable UDP communication SE.IoTMx TM I/O services for M251d/M262d Library of hardware CATs for TMp I/O modules used for M251d and M262d hardware configuration SE.IoX80 X80 I/O services for M580d Library of hardware CATs for X80 I/O modules used for M580d hardware configuration SE.ModbusGateway Standard Modbus gateway Library of hardware CATs to enable Modbus TCP communication with standard Modbus devices SE.StandardEcoStruxureAutomationExpert HMI device type Standard EcoStruxure Automation Expert HMI device type Standard IoEthNetIP Standard Ethernet IP scanner functions Library of hardware CATs used for EIP scanner configuration and functionality SE.StandardModbus Standard Modbus TCP/IP gateway Library of hardware CATs to enable Modbus client communication Standard.IoModbus Standard Modbus functions Library of hardware CATs to enable Modbus client communication Standard.IoModbusSlave Standard Modbus server functions Library of hardware CATs to enable Modbus server communication Standard.OPCUAClient Standard OPC UA client functions Functions to enable OPC UA client connection, monitor, read, and write data Definitions: b CAT object: A composite automation type (CAT) function block includes objects with multiple facets: v Logic to define its operating modes v I/O interfaces to exchange data/events with its environment v Symbols/faceplates for control and monitoring in the HMI v Documentation that is implicitly part of the project online help b Application CAT: representing application assets or functions b Hardware CAT: representing hardware devices that can be added to the hardware configuration, for device monitoring and control 9 Industrial automation systems EcoStruxure Automation Expert Software Presentation (continued) EcoStruxure Automation Expert Software (continued) System requirements Minimum Performance Logging and HMI Archive System requirements Minimum Performance Logging and HMI Archive Processor 1 GHz 2-GHz or higher Hard disk 2 GB 2 GB 4 GB 4 GB 4 GB 4 GB Hard disk free space (1) 1 GB 1 GB 1 GB 10 GB 10 GB 10 GB Display resolution 1280x1024 1920x1080 or higher Pointing device Mouse or compatible Network access One Ethernet interface Operating system Microsoft Windows 10 Professional (64-bit) Version 1903 and later, Microsoft Windows 11 Professional Version 21H2 and later, and Microsoft Windows 11 Professional Version 21H2 and later Server 2019 (1809 and later) .NET framework .NET 4.8 .NET 4.8 or higher (1) Requirement is indicated for each software package. More than one software package can be installed on the same device. In this case, you need to add the respective RAM and hard disk free space requirements together. For example, if you install the HMI and Archive software packages on the same device, the minimum RAM required is 4 GB (2 GB + 2 GB). 17 Industrial automation systems EcoStruxure Automation Expert Architecture Presentation (continued) Types of standard architectures EcoStruxure Automation Expert breaks the dependency between the application software and the hardware platform it runs. Together with its distribution capabilities, EcoStruxure Automation Expert is a unique automation solution to be used in any kind of architecture, from small machines up to complex process architecture. Example of Soft dPAC standard architecture The EcoStruxure Automation Expert architecture for small machines increases engineering efficiency by using the Automatically generated network transparent communications between controller and HMI objects with many-to-many connectivity and communication protocol that fits the application needs. Example of Soft dPAC redundant architecture The redundancy capability of the EcoStruxure Automation Expert Runtime helps to increase the availability of the automation system. Example of Hot Standby Redundant Architecture with Modicon M580 dPAC, Modicon CRD for Simplex/High Availability Soft dPAC (Linux OS) Modicon M580 dPAC, Modicon CRD for Simplex/High Availability Soft dPAC (Linux OS) Type Reference Description Compatibility with Modicon M580 dPAC Compatibility with Modicon CRD for Simplex/High Availability Soft dPAC (Linux OS) Rack BMEXBP0400 4-slot Ethernet backplane Yes Yes Rack BMEXBP0400H Ruggedized 4-slot Ethernet backplane Yes Yes Rack BMEXBP0602 6-slot Ethernet backplane redundant PS Yes Yes Rack BMEXBP0602H Ruggedized 6-slot Ethernet backplane redundant PS Yes Yes Rack BMEXBP0800 8-slot Ethernet backplane Yes Yes Rack BMEXBP0800H Ruggedized 8-slot Ethernet backplane Yes Yes Rack BMEXBP1002 10-slot Ethernet backplane redundant PS Yes Yes Rack BMEXBP1002H Ruggedized 10-slot Ethernet backplane redundant PS Yes Yes Rack BMEXBP1200 12-slot Ethernet backplane Yes Yes Rack BMEXBP1200H Ruggedized 12-slot Ethernet backplane Yes Yes Rack BMEXBP0064 Ethernet backplane extension cable 0.4 m/1.31 ft Yes Yes Rack BMEXBP0120 Ethernet backplane extension cable 1.2 m/3.93 ft Yes Yes Rack BMEXBP0300 Ethernet backplane extension cable 3 m/9.84 ft Yes Yes Rack BMEXBP0800 Ethernet backplane extension cable 12 m/39 ft Yes Yes Rack BMXXBE1000 Standard backplane extender Yes Yes Rack BMXXBE1000H Ruggedized standard backplane extender Yes Yes Rack BMXXBE2005 Backplane extender kit Yes Yes Rack BMXXBP0400 4-slot backplane Yes Yes Rack BMXXBP0400H Ruggedized 4-slot backplane Yes Yes Rack BMXXBP0600 6-slot backplane Yes Yes Rack BMXXBP0800 8-slot backplane Yes Yes Rack BMXXBP0800H Ruggedized 8-slot backplane Yes Yes Rack BMXXBP0800H Ruggedized 8-slot backplane Yes Yes Rack BMXXBP1200 12-slot backplane Yes Yes Rack BMXXBP1200H Ruggedized 12-slot backplane Yes Yes Rack BMXXBP1200H Ruggedized 12-slot backplane Yes Yes Rack BMXXBP0064 Ethernet backplane extension cable 0.4 m/1.31 ft Yes Yes Rack BMXXBP0120 Ethernet backplane extension cable 1.2 m/3.93 ft Yes Yes Rack BMXXBP0300 Ethernet backplane extension cable 3 m/9.84 ft Yes Yes Rack BMXXBP0800 Ethernet backplane extension cable 12 m/39 ft Yes Yes Rack BMXXBE1000 Standard backplane extender Yes Yes Rack BMXXBE1000H Ruggedized standard backplane extender Yes Yes Rack BMXXBE2005 Backplane extender kit Yes Yes Rack BMXXBP0400 4-slot backplane Yes Yes Rack BMXXBP0400H Ruggedized 4-slot backplane Yes Yes Rack BMXXBP0600 6-slot backplane Yes Yes Rack BMXXBP0800 8-slot backplane Yes Yes Rack BMXXBP0800H Ruggedized 8-slot backplane Yes Yes Rack BMXXBP0800H Ruggedized 8-slot backplane Yes Yes Rack BMXXBP1200 12-slot backplane Yes Yes Rack BMXXBP1200H Ruggedized 12-slot backplane Yes Yes Rack BMXXBP1200H Ruggedized 12-slot backplane Yes Yes Rack BMXMRSM004GPF Optional M580 SD card 4 GB Yes No Analog I/O BMXAMI0410 4 voltage/current isolated high-speed analog inputs Yes Yes Analog I/O BMXAMI0810 8 voltage/current isolated high-level analog inputs Yes Yes Analog I/O BMXAMI0810H Ruggedized 8 voltage/current isolated high-level analog inputs Yes Yes Analog I/O BMXAMI0410 4 voltage/current non-isolated fast analog inputs Yes Yes Analog I/O BMXAMI0810 8 voltage/current non-isolated fast analog inputs Yes Yes Analog I/O BMXAMI0810H Ruggedized 8 voltage/current non-isolated fast analog inputs Yes Yes Analog I/O BMXAMO0802 8 current non-isolated analog outputs Yes Yes Analog I/O BMXAMM0600 4 analog inputs - 2 analog outputs Yes No Analog I/O BMXAMM0600H Ruggedized 4 analog inputs - 2 analog outputs Yes No Analog I/O BMXAMO0210 2 isolated analog outputs Yes No Analog I/O BMXART0814 8 isolated TC/RTD inputs Yes Yes Analog I/O BMXART0814H Ruggedized 8 isolated TC/RTD inputs Yes Yes Analog I/O BMEAHI0812 8 current isolated analog inputs, HART No Yes Analog I/O BMEAHO0412 4 current isolated high-level analog outputs, HART No Yes Power BMXCPS2000 Standard AC power supply Yes Yes Power BMXCPS2010 Standard isolated DC power supply Yes Yes Power BMXCPS3020 High-power isolated 24 V to 48 V DC power supply Yes Yes Power BMXCPS3020H High-power AC power supply Yes Yes Power BMXCPS4002 Redundant high-power AC power supply Yes Yes Power BMXCPS4022 Redundant high-power DC power supply Yes Yes Power BMXCPS4022H Ruggedized high-power DC power supply Yes Yes Power BMXCPS5220 Redundant 125 V DC power supply Yes Yes Power BMXCPS5220H Ruggedized redundant 125 V DC power supply Yes Yes Power BMXCPS3500 High-power AC power supply Yes Yes Power BMXCPS3500H Ruggedized high-power AC power supply Yes Yes Power BMXCPS3522 Redundant 125 V DC power supply Yes Yes Power BMXCPS3522H Ruggedized redundant 125 V DC power supply Yes Yes Discrete I/O BMXDDI1602 16 24 V DC source input modules Yes Yes Discrete I/O BMXDDI1602H Ruggedized 16 24 V DC source input modules Yes Yes Discrete I/O BMXDDI3202K 32k 24 V DC sink discrete inputs Yes No Discrete I/O BMXDDI6402K 64k 24 V DC sink discrete inputs Yes Yes Discrete I/O BMXDDM16025 8x 24 V DC discrete inputs, 8x discrete relay outputs Yes No Discrete I/O BMXDDM16025H Ruggedized 8x 24 V DC discrete inputs, 8x discrete relay outputs Yes No Discrete I/O BMXDDO1602 16 transistor source 0.5 A discrete outputs Yes Yes 29 Compatibility (continued) Industrial automation systems EcoStruxure Automation Expert Product compatibility according to dPAC platform List of Modicon X80 hardware compatible with Modicon M580 dPAC, Modicon CRD for Simplex/High Availability Soft dPAC (Linux OS) Type Reference Description Compatibility with Modicon M580 dPAC Compatibility with Modicon CRD for Simplex/High Availability Soft dPAC (Linux OS) Discrete I/O BMXDDO1602H Ruggedized 16 transistor source 0.5 A discrete outputs Yes Yes Discrete I/O BMXDRA0815 8 isolated relay outputs Yes No Discrete I/O BMXDRA0815H Ruggedized 8 isolated relay outputs Yes No Discrete I/O BMXDRA1605 16 discrete relay outputs Yes No Discrete I/O BMXDRA1605H Ruggedized 16 discrete relay outputs Yes No Discrete I/O BMXDAI0814 8x 100...120 V AC isolated inputs Yes No Discrete I/O BMXDAI1604 16x 100...120 V AC capacitive inputs Yes No Discrete I/O BMXDAI1604H Ruggedized 16x 100...120 V AC capacitive inputs Yes No Discrete I/O BMXDAO1605 16x 100...240 V AC triac outputs Yes No Discrete I/O BMXDAO1605H Ruggedized 16x 100...240 V AC triac outputs Yes No Discrete I/O BMXDDM16022 8 inputs - 24 V DC - 8 outputs - solid state Yes No Discrete I/O BMXDDM16022H 8 inputs - 24 V DC - 8 outputs - solid state- severe environment Yes No Discrete I/O BMXDMM3202K 16x 24 V DC inputs - 16x solid state outputs Yes No Other BMXNRP0200 Fiber converter MM/LC 2-channel, 100 m/328 ft Yes No Other BMXNRP0201 Fiber converter SM/LC 2-channel, 100 m/328 ft Yes No Other BMXECO0800 8 high-speed counter channels Yes No Expert BMXEHC0800H Ruggedized 8 high-speed counter channels Yes No Expert BMXEAE0300 3-channel SSI encoder interface module Yes No Expert BMXERT1604H Ruggedized 4-channel RTD/TC/Ohm/mV input module Yes No Expert BMXMSP0200 Modbus serial line master/slave module Yes No Expert BMXNOM0200 Modbus serial line master/slave module Yes No Expert BMXNOR0200H Ruggedized serial line master/slave module Yes No Expert BMXNOR0200H Ruggedized serial line master/slave module Other TM3XTYS4 TM3 motion transmitter module Other TM3XTYS4C TM3 motion transmitter module Other TM3XTYS4G TM3 motion transmitter module Other TM3XTYS4GC TM3 motion transmitter module Other TM3XTYS4GC2020 Hardware support module 2 HSC 2020 Hz, 10 inputs, 8 outputs Yes Yes Dual USA and Canada: Hazardous location class I, division 2, groups A, B, C, and D v For other countries: CE ATEX (2014/34/EU) or IECEx in defined atmosphere Zone 2 (gas) and/or Zone 22 (dust) b Merchant navy requirements of the major international organizations: unified in IACS (International Association of Classification Societies) b Compliance with European Directives for CE marking: v Low voltage: 2014/35/EU v Electromagnetic compatibility: 2014/30/EU v Machinery: 2006/42/EC Up-to-date information on which certifications have been obtained is available on our website. Modicon M580 dPACs are considered as open equipment and are designed for use in industrial environments, in pollution degree 2, overvoltage category II (IEC 60664-1), and in low-voltage installations, where the main power branch is protected on both wires by devices such as fuses or circuit breakers limiting the current to 15 A for North America and 16 A for the rest of the world. Industrial automation systems EcoStruxure Automation Expert Product compatibility according to dPAC platform M580 dPAC BMED581020 EAE_23643079_OPSPH20002 Characteristics Operating conditions and recommendations relating to the environment Modicon M580 dPAC automation platform Modicon M580 dPAC harsh I/O platform Temperature Operation 0...60 °C/32...140 °F -25...+70 °C/-13...158 °F Storage -40...85 °C/-40...185 °F -40...85 °C/-40...185 °F Relative humidity (without condensation) Cyclical humidity 5...95% up to 55 °C/131 °F

5...95% up to 55 °C/131 °F Continuous humidity 5...93% up to 55 °C/131 °F 5...93% up to 60 °C/140 °F Altitude Operation 0…2,000 m/0...6,562 ft (full specification: temperature and isolation) 2,000...5,000 m/6,562...16,404 ft (temperature derating: approx. 1 °C/400 m (33.8 °F/1,312 ft), isolation 150 V/1,000 m (3,281 ft)) For accurate temperature derating calculation, refer to IEC 61131-2 Ed 4.0 Annex A Modicon X80 I/O power supply modules BMXCPS2010 BMXCPS3020 BMXCPS3020H BMXCPS3540T BMXCPS2000 BMXCPS3500 BMXCPS3500H BMXCPS4002 Supply voltage Nominal voltage 24 V c 24...48 V c 125 V c 100...240 V a 100...240 V a Limit voltages 18...31.2 V c 18...62.4 V c 100...150 V c 85...264 V a 85...264 V a Nominal frequencies – – – 50/60 Hz 50/60 Hz Limit frequencies – – – 47/63 Hz 47/63 Hz 33 Protective treatment of the Modicon M580 dPAC automation platform The Modicon M580 dPAC platform meets the requirements of "TC" treatment (treatment for all climates). For installations in industrial production workshops or environments corresponding to "TH" treatment (treatment for hot and humid environments), Modicon M580 dPAC must be embedded in enclosures with minimum IP54 protection. The Modicon M580 dPAC platform offers protection to IP20 level and protection against access to terminals (enclosed equipment) (1). They can therefore be installed without an enclosure in reserved-access areas that do not exceed pollution level 2 (control room with no dust-producing machine or activity). Pollution level 2 does not take account of more severe environmental conditions: air pollution by dust, smoke, corrosive or radioactive particles, vapors or salts, molds, insects, etc. (1) In cases where a slot is not occupied by a module, a BMXXEM010 protective cover must be installed. (e): Tests required by European directives (e) and based on IEC/EN 61131-2 standards. Environment tests Immunity to LF interference (e) (1) Name of test Standards Levels Voltage and frequency variations IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11 0.85...1.10 Un - 0.94...1.04 Fn; 4 steps t = 30 min IACS E10; IEC 61000-4-11 0.80 Un...0.90 Fn; 1.20 Un...1.10 Fn; t = 1.5 s/5 s Direct voltage variations IEC/EN 61131-2; IEC 61000-4-29; IACS E10 (PLC not connected to charging battery) 0.85...1.2 Un + ripple: 5% peak; 2 steps t = 30 min Third harmonic IEC/EN 61131-2 H3 (10% Un), 0°/180°; 2 steps t = 5 min Voltage interruptions IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11; IEC 61000-4-29; IACS E10 Power supply immunity: b 10 ms for a and c PS2 (20 ms DS criteria) b Check operating mode for longer interruptions up to 5 s, 85% Un b For IACS, 3 times 30 s in 5 min, 85% Un IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11 For a PS2: b 20% Un, t0: ½ period b 40% Un, cycle 10/12 b 70% Un, cycle 25/30 b 0% Un, cycle 250/300 Voltage shut-down and start-up IEC/EN 61131-2 b Un…0…Un; t = Un/60 s b Umin…0…Umin; t = Umin/5 s b Umin…0.9 Udl…Umin; t = Umin/60 s Magnetic field IEC/EN 61131-2; IEC 61000-4-8 (for MV power stations: IEC 61000-6-5; IEC 61850-3) Power frequency: 50/60 Hz, 100 A/m continuous ...1,000 A/m; t = 3 s; 3 axes IEC 61000-4-10 Oscillatory: 100 kHz...1 MHz, 100 A/m; t = 9 s; 3 axes Conducted common mode disturbances range 0 Hz …150 kHz IEC 61000-4-16 (for MV power stations: IEC 61000-6-5; IEC 61850-3) For remote systems: b 50/60 Hz and c, 300 V, t = 1s b 50/60 Hz and c, 30 V, t = 1 min b 5 Hz…150 kHz, sweep 3 V…30 b For a: 10 V b For c: 10 V cont. or 100 V, t = 1 s Where: b PS1 applies to PLC supplied by battery, PS2 applies to PLC energized from a or c supplies b Un: nominal voltage; Fn: nominal frequency; Udl: detection level with power on (1) Devices must be installed, wired, and maintained in accordance with the instructions provided in the manual "Grounding and Electromagnetic Compatibility of PLC Systems". (2) These tests are performed without an enclosure, with devices fixed on a metal grid and wired as per the recommendations in the manual "Grounding and Electromagnetic Compatibility of PLC systems". (e): Tests required by European directives (e) and based on IEC/EN 61131-2 standards. References (continued) Industrial automation systems EcoStruxure Automation Expert Modicon M580 dPAC 34 References (continued) Modicon CRD, I/O bus over Ethernet for Simplex/High Availability Soft dPAC (Linux OS) RSTP Communication ports Service ports Reference Weight kg/lb 2 1 BMECRD0100 BMECRD0100C 0.848/ 1.872 Standards and certifications The Modicon CRD platform has been developed to comply with the principal national and international standards concerning electronic equipment for industrial automation systems. b Requirements specific to programmable controllers: functional characteristics, immunity, resistance, etc.: IEC/EN 61131-2 and IEC/EN/UL/CSA 61010-2-201 b Requirements specific to power utility automation systems: IEC/EN 61000-6-5, IEC/EN 61850-3 (with installation restrictions) b Requirements specific to railway applications: EN 50155/IEC 60571 (with installation restrictions) b Hazardous areas: v For USA and Canada: Hazardous location class I, division 2, groups A, B, C, and D v For other countries: CE ATEX (2014/34/EU) or IECEx in defined atmosphere Zone 2 (gas) and/or Zone 22 (dust) b Merchant navy requirements of the major international organizations: unified in IACS (International Association of Classification Societies) b Compliance with European Directives for CE marking: v Low voltage: 2014/35/EU v Electromagnetic compatibility: 2014/30/EU v Machinery: 2006/42/EC Up-to-date information on which certifications have been obtained is available on our website. Modicon CRD is considered as open equipment and are designed for use in industrial environments, in pollution degree 2, overvoltage category II (IEC 60664-1), and in low-voltage installations, where the main power branch is protected on both wires by devices such as fuses or circuit breakers limiting the current to 15 A for North America and 16 A for the rest of the world. Industrial automation systems EcoStruxure Automation Expert Modicon Ethernet Remote I/O BMECRD0100 BMECRD0100_main Characteristics Service conditions and recommendations relating to the environment Modicon CRD automation platform Modicon CRD harsh I/O platform Temperature Operation 0...60 °C/32...140 °F -25...+70 °C/-13...158 °F Storage -40...85 °C/-40...185 °F -40...85 °C/-40...185 °F Relative humidity (without condensation) Cyclical humidity 5...95% up to 55 °C/131 °F 5...95% up to 55 °C/131 °F 5...93% up to 60 °C/140 °F Altitude Operation 0…2,000 m/0...6,562 ft (full specification: temperature and isolation) 2,000...5,000 m/6,562...16,404 ft (temperature derating: approx. 1 °C/400 m (33.8 °F/1,312 ft), isolation 150 V/1,000 m (3,281 ft)) For accurate temperature derating calculation, refer to IEC 61131-2 Ed 4.0 Annex A Modicon X80 I/O power supply modules BMXCPS2010 BMXCPS3020 BMXCPS3020H BMXCPS3540T BMXCPS2000 BMXCPS3500 BMXCPS3500H BMXCPS4002 BMXCPS4002S BMXCPS4002H Supply voltage Nominal voltage 24 V c 24...48 V c 125 V c 100...240 V a 100...240 V a Limit voltages 18...31.2 V c 18...62.4 V c 100...150 V c 85...264 V a 85...264 V a Nominal frequencies – – – 50/60 Hz 50/60 Hz Limit frequencies – – – 47/63 Hz 47/63 Hz 35 Protective treatment of the Modicon CRD automation platform The Modicon CRD platform meets the requirements of "TC" treatment (treatment for all climates). For installations in industrial production workshops or environments corresponding to "TH" treatment (treatment for hot and humid environments), Modicon CRD must be embedded in enclosures with minimum IP54 protection. The Modicon CRD platform offers protection to IP20 level and protection against access to terminals (enclosed equipment) (1). They can therefore be installed without an enclosure in reserved-access areas that do not exceed pollution level 2 (control room with no dust-producing machine or activity). Pollution level 2 does not take account of more severe environmental conditions: air pollution by dust, smoke, corrosive or radioactive particles, vapors or salts, molds, insects, etc. (1) In cases where a slot is not occupied by a module, a BMXXEM010 protective cover must be installed. (e): Tests required by European directives (e) and based on IEC/EN 61131-2 standards. Environment tests Immunity to LF interference (e) (1) Name of test Standards Levels Voltage and frequency variations IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11 0.85...1.10 Un - 0.94...1.04 Fn; 4 steps t = 30 min IACS E10; IEC 61000-4-11 0.80 Un...0.90 Fn; 1.20 Un...1.10 Fn; t = 1.5 s/5 s Direct voltage variations IEC/EN 61131-2; IEC 61000-4-29; IACS E10 (PLC not connected to charging battery) 0.85...1.2 Un + ripple: 5% peak; 2 steps t = 30 min Third harmonic IEC/EN 61131-2 H3 (10% Un), 0°/180°; 2 steps t = 5 min Voltage interruptions IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11; IEC 61000-4-29; IACS E10 Power supply immunity: b 10 ms for a and c PS2 (20 ms DS criteria) b Check operating mode for longer interruptions up to 5 s, 85% Un b For IACS, 3 times 30 s in 5 min, 85% Un IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11 For a PS2: b 20% Un, t0: ½ period b 40% Un, cycle 10/12 b 70% Un, cycle 25/30 b 0% Un, cycle 250/300 Voltage shut-down and start-up IEC/EN 61131-2 b Un…0…Un; t = Un/60 s b Umin…0…Umin; t = Umin/5 s b Umin…0.9 Udl…Umin; t = Umin/60 s Magnetic field IEC/EN 61131-2; IEC 61000-4-8 (for MV power stations: IEC 61000-6-5; IEC 61850-3) Power frequency: 50/60 Hz, 100 A/m continuous ...1,000 A/m; t = 3 s; 3 axes IEC 61000-4-10 Oscillatory: 100 kHz...1 MHz, 100 A/m; t = 9 s; 3 axes Conducted common mode disturbances range 0 Hz …150 kHz IEC 61000-4-16 (for MV power stations: IEC 61000-6-5; IEC 61850-3) For remote systems: b 50/60 Hz and c, 300 V, t = 1s b 50/60 Hz and c, 30 V, t = 1 min b 5 Hz…150 kHz, sweep 3 V…30 b For a: 10 V b For c: 10 V cont. or 100 V, t = 1 s Where: b PS1 applies to PLC supplied by battery, PS2 applies to PLC energized from a or c supplies b Un: nominal voltage; Fn: nominal frequency; Udl: detection level with power on (1) Devices must be installed, wired, and maintained in accordance with the instructions provided in the manual "Grounding and Electromagnetic Compatibility of PLC Systems". (2) These tests are performed without an enclosure, with devices fixed on a metal grid and wired as per the recommendations in the manual "Grounding and Electromagnetic Compatibility of PLC systems". (e): Tests required by European directives (e) and based on IEC/EN 61131-2 standards. References (continued) Industrial automation systems EcoStruxure Automation Expert Modicon M251 dPAC Ethernet Remote I/O 36 Modicon M251 dPAC Local I/O capacity Device ports Service ports Reference Weight kg/lb No embedded I/O, supporting Modicon TM3 I/O expansion modules 2 1 TM251MDESE 0.848/ 1.872 Standards and certifications b Standards v IEC/EN 61131-2 (Edition 2 2007) v UL508 v ANSI/ISA 12.12.01-2007 v CSA C22.2 No. 213 and No. 142 b Certifications v e v cULus Listing Mark v RCM v Achilles v UKCA Environmental characteristics Service conditions and recommendations relating to the environment Temperature Operation Vertical installation: -10...55 °C/14...122 °F Horizontal installation: -10...55 °C/14...131 °F Storage -40...70 °C/-40...158 °F Relative humidity (without condensation) Operation 10...95% Storage Altitude Operation 0…2,000 m/0...6,562 ft: complete specification for temperature and exposure Storage 0…3,000 m (0...9,842 ft) Immunity to mechanical stress 1131 b Rail mounting: v 5...8.4 Hz (amplitude 3.5 mm/0.138 in.) v 8.4…150 Hz (acceleration 1 g) b Panel mounting: v 8.7…150 Hz (acceleration 3 g) Merchant Navy 2…13.2 Hz (amplitude 1.0 mm/0.039 in.) 13.2…100 Hz (acceleration 0.7 g) Supply characteristics Power supply 24 V c Voltage limit Including ripple 19.2...28.8 V c Immunity to micro-cuts Class PS-2 10 ms Max. consumption 45 W References (continued) Industrial automation systems EcoStruxure Automation Expert Modicon M251 dPAC TM251MDESE EAE_23643079_OPSPH20005 37 Modicon M251 dPAC Local I/O capacity Device ports Service ports Reference Weight kg/lb No embedded I/O, supporting Modicon TM3 I/O expansion modules 2 1 TM262L01MDESE8T 0.655/ 1.444 Standards and certifications b Standards v IEC/EN 61131-2 (Edition 2 2007) v UL 61010-1, 61010-2-201 v ANSI/ISA 12.12.01-2007 v CSA C22.2 No. 213, No. 61010-1, No. 61010-2-201 b Certifications v e v cULus, cULus HazLoc Class I Division 2 CSA C22.2 No 213 v RCM v Achilles v KC v EAC Environmental characteristics Service conditions and recommendations relating to the environment Temperature Operation Vertical installation: -20...50 °C/-4...122 °F Horizontal installation: -20...60 °C/-4...140 °F Flat mounting: -20...45 °C/-4...113 °F Storage -40...85 °C/-40...185 °F Relative humidity (without condensation) Operation 5...95% Storage Altitude Operation 0…2,000 m/0...6,562 ft Storage 0…3,000 m (0...9,842 ft) Immunity to mechanical stress 3.5 mm at 2…8.4 Hz 1 gn at 8.4…200 Hz Supply characteristics Power supply 24 V c (-15...20%) Voltage limit 20.4...28.8 V c Immunity to micro-cuts 0.01 ms Max. consumption 82 W References (continued) Industrial automation systems EcoStruxure Automation Expert Modicon M262 dPAC Modicon M262 dPAC module TM262L01MDESE8T_image 38 Altivar ATV dPAC ATV dPAC module Local I/O capacity Device ports Service ports Reference Weight kg/lb Supporting Altivar Drives I/O embedded, expansion and encoder modules: b Up to 23 discrete I/O b Up to 7 analog I/O b 12 MB integrated memory 2 – VW3A3530D 0.020/ 0.044 Standards and certifications Depending on the specific drive type used for ATV dPAC integration, the standards and certifications must be checked in the corresponding ATV340/600/900 manual. b Standards v EN/IEC 61800-3 v IEC 61800-5-1/2 v IEC 60721-3-3 v IEC 61508 v SEMI F47-0706 v UL508C and UL61800-5-1 v RoHS-2 according to EU directive 2002/95/EC v REACH according to EU regulation 1907/2006 b Certifications v CE v UL v CSA v RCM v EAC v ATEX v DNV-GL Environmental characteristics Altivar Process and Altivar Machine drives are designed to operate in a variety of environments, including harsh environments. The conditions stated below are general data and must be verified with the respective ATV600, ATV900, and ATV340 manuals for the specific drive type used. Service conditions and recommendations relating to the environment Temperature Operation As standard: -15...50 °C/+5...122 °F With derating: -15...60 °C/+5...140 °F Storage and transport -40...70 °C/-40...158 °F Relative humidity (without condensation) Operation 5...95% Storage Altitude Operation b 0…1,000 m/0…3,281 ft without derating b 1,000…4,800 m/3,281…15,700 ft with derating of 1% per 100 m/328 ft Protection of devices IP20 to IP55 Withstand to harsh environment b Chemical class 3C3 conforming to IEC/EN 60721-3-3 b Mechanical class 3S3 conforming to IEC/EN 60721-3-3 b Printed circuit boards with protective coating Environmental characteristics Compliance with electromagnetic compatibility requirements has been incorporated into the design of Altivar Process and Altivar Machine drives. They are e marked according to the European EMC directive (2014/30/EU). Note: Depending on the specific drive type used for ATV dPAC integration, the EMC compliance values must be checked in the corresponding ATV340/600/900 manual. References (continued) Industrial automation systems EcoStruxure Automation Expert Altivar ATV dPAC VW3A3530D EAE_23643079_OPSPH20001 39 Graphic display terminal Description Reference Weight kg/lb To be used with ATV340 (ATV600 and ATV900 are equipped with the graphic display terminal as standard) Display 240 x 160 pixels, 8 lines Real-time clock with 10-year backup battery, to keep time when the drive is powered off Protection IP65 To be procured separately for ATV340 (delivered as standard with ATV600 and ATV900) VW3A1111 0.020/ 0.044 Remote mounting kit Description Reference Weight kg/lb Remote mounting kit For remote mounting of graphic display terminal, suitable for ATV340, ATV600, and ATV900 families Protection IP65 VW3A1112 0.020/ 0.044 Remote mounting cordset Description Length (m/ft) Reference Weight kg/lb Remote mounting cordset Equipped with 2 RJ45 connectors for connection of the graphic display terminal to the drive 1/ 3.28 VW3A1104R10 0.050/ 0.110 3/ 9.84 VW3A1104R30 0.150/ 0.331 5/ 16.4 VW3A1104R50 0.250/ 0.551 10/ 32.8 VW3A1104R100 0.500/ 1.102 Connector cable Description Length (m/ft) Reference Weight kg/lb USB/Mini B USB cable for connecting the graphic display terminal to a PC – TCSXCNAMUM3P – VW3A1111 VW3A1112 PF130899PF130903 TCSXCNAMUM3P VW3A1104R10 EAE_23643079_OPSPH20003 References (continued) Industrial automation systems EcoStruxure Automation Expert Altivar ATV dPAC 40 Services Industrial automation systems Schneider Electric offers lifecycle services for your industrial automation systems based on EcoStruxure Automation Expert. Our lifecycle services include field and digital services. We believe, with our advanced processes and tools, we are your trusted expert in field and digital services to help you achieve greater functional safety, efficiency, sustainability, and resilience in your plant operations. We offer services that are designed to address your needs as you plan, install, operate, and optimize your industrial automation systems based on EcoStruxure Automation Expert. These include: b Consulting services b Maintenance and support services b Training Services b Migration Services For more information, visit our Industrial Automation Services page. Consulting services Consulting services are about bringing our expertise to help find solutions to some of your key operational challenges. Be it about maximizing the business value from your digital transformation initiatives, identifying improvement opportunities in your industrial automation system lifecycle management plans, or improving your cybersecurity posture and compliance, we can help. Take a look at some of our consulting offerings: Security consulting Our cybersecurity consultants will help you assess and review your EcoStruxure Automation Expert systems to detect gaps, identify risks, uncover any security malpractices, assess your staff's security competencies, provide emergency response services, and more. For more information, visit our Cybersecurity Services page. IA lifecycle consulting Audits performed by our service team provide insights and recommendations to help improve the maintenance plans of industrial automation assets. This service helps identify potential risks to the reliability and maintainability of these assets and plan mitigation actions. Watch the video to learn more about our IA Lifecycle Consulting Service. Maintenance and support services Our maintenance and support offerings help you quickly restore your operations in the event of an unplanned downtime incident. They can also help reduce the risk of occurrence and the associated costs. Take a look at some of our maintenance and support offerings: Extended warranty The extended warranty offer gives you the option to extend the warranty of selected Schneider Electric hardware by up to three years. Note: Please contact your Customer Care Center for offer availability. Spare parts, exchanges, and repairs These solutions help you to respond, in the most optimal manner, to requests for spare parts for your EcoStruxure Automation Expert system based on Schneider Electric hardware. Services include: b Parts management service: Onsite or shared spares inventory, managed by us, to help ensure parts availability, while optimizing costs. b Repair: Product repairs performed onsite when possible, or at our repair centers. b Exchange: A refurbished product is provided in exchange for a product returned with a detected fault. Note: Availability of these services may vary depending on the applicable Schneider Electric hardware. Please contact your Customer Care Center for offer availability. 41 Services (continued) Industrial automation systems Maintenance and support services (continued) Maintenance and support contracts Our Support and Maintenance Service Offers, are a simplified and modular annual support services agreements, designed to provide you with the right level of flexibility and confidence to meet your support and maintenance needs for your industrial automation systems based on EcoStruxure Automation Expert. Available as Advantage Service Plan (ASP) for Automation Control or as Customer FIRST (CF) Program for Automation Control, they offer a pre-packaged set of services relevant to operating & maintaining an EcoStruxure Automation Expert Systems. For further customization, a set of optional services are available. The following table provides a snapshot of the plan: Included Services Support Levels ASP CF Essential Primary Core Support and Services Priority Technical Support Access – NBH(a) SLA(b) SLA (b) myScheider Portal Access – Premium support Yes Yes Software Version Update(c) Yes Yes Optional services(d) 24/7 Priority Technical Support – Phone Block of Support Hours (a) Normal Business Hours (b) Service Level Agreement (c) Excludes labor and hardware (d) Subject to local availability With the enhancements to EcoStruxure Automation Expert V24.0 licensing system, we will progressively offer a more digital experience for customers seeking to maintain the currency of their EcoStruxure Automation Expert software. With this experience, customers with our support and maintenance service offers, will be able to update, in a self-service mode, their EcoStruxure Automation Expert software installation, as and when installations are ready. Please contact your Customer Care Center for offer availability. Training services Our training services are designed for users to take maximum advantage of our industrial automation systems based on EcoStruxure Automation Expert. Our training catalog includes courses on: b Automation fundamentals b IEC 61499 concepts b EcoStruxure Automation Expert engineering and configuration For more information, please visit our Learning Services Home Page or send us an email. Modernization and migration services Over the years, we have been involved in migrating many major automation systems to Schneider Electric. Our migration services, based on this expertise and complemented by a set of dedicated tools, help to minimize the risks and costs involved in such upgrades to an open EcoStruxure Automation Expert-based system. The available set of tools and services are outlined below: Tools and services Source platforms Tools and services Reverse engineering Application conversion service Wiring systems for Modicon X80 Schneider Electric Modicon Premium Yes 2023 Yes Rockwell Automation SLC 500 Yes Yes Yes PLC-5 Yes Yes ControlLogix Yes 2023 _ In addition to the above, we can also offer project-specific solutions. Please contact your local service teams for more information. 42 Industrial automation systems EcoStruxure Automation Expert Product reference index Index A ATV340D11N4 31 ATV340D11N4E 31 ATV340D15N4 31 ATV340D15N4E 31 ATV340D18N4 31 ATV340D18N4E 31 ATV340D22N4 31 ATV340D22N4E 31 ATV340D30N4 31 ATV340D30N4E 31 ATV340D37N4 31 ATV340D37N4E 31 ATV340D45N4 31 ATV340D45N4E 31 ATV340D55N4 31 ATV340D55N4E 31 ATV340D75N4 31 ATV340D75N4E 31 ATV340U07N4 31 ATV340U07N4E 31 ATV340U15N4 31 ATV340U15N4E 31 ATV340U22N4 31 ATV340U22N4E 31 ATV340U30N4 31 ATV340U30N4E 31 ATV340U40N4 31 ATV340U40N4E 31 ATV340U55N4 31 ATV340U55N4E 31 ATV340U75N4 31 ATV340U75N4E 31 ATV630C11N4 31 ATV630C13N4 31 ATV630C16N4 31 ATV630C20N4F 31 ATV630C22N4 31 ATV630C25N4F 31 ATV630C31N4F 31 ATV630D11N4 31 ATV630D15N4 31 ATV630D18N4 31 ATV630D22N4 31 ATV630D30N4 31 ATV630D37N4 31 ATV630D45N4 31 ATV630D55N4 31 ATV630D75N4 31 ATV630D90N4 31 ATV630U07N4 31 ATV630U15N4 31 ATV630U22N4 31 ATV630U30N4 31 ATV630U40N4 31 ATV630U55N4 31 ATV630U75N4 31 ATV650C11N4F 31 ATV650C13N4F 31 ATV650C16N4F 31 ATV650C20N4F 31 ATV650C25N4F 31 ATV650C31N4F 31 ATV650D11N4 31 ATV650D11N4E 31 ATV650D15N4 31 ATV650D15N4E 31 ATV650D18N4 31 ATV650D18N4E 31 ATV650D22N4 31 ATV650D22N4E 31 ATV650D30N4 31 ATV650D30N4E 31 ATV650D37N4 31 ATV650D37N4E 31 ATV650D45N4 31 ATV650D45N4E 31 ATV650D55N4 31 ATV650D55N4E 31 ATV650D75N4 31 ATV650D75N4E 31 ATV650D90N4 31 ATV650D90N4E 31 ATV650U07N4 31 ATV650U07N4E 31 ATV650U15N4 31 ATV650U15N4E 31 ATV650U22N4 31 ATV650U22N4E 31 ATV650U30N4 31 ATV650U30N4E 31 ATV650U40N4 31 ATV650U40N4E 31 ATV650U55N4 31 ATV650U55N4E 31 ATV650U75N4 31 ATV650U75N4E 31 ATV660C11T4X1 31 ATV660C13T4X1 31 ATV660C16T4X1 31 ATV660C20T4X1 31 ATV660C25T4X1 31 ATV660C31T4X1 31 ATV660C35Q4X1 31 ATV660C40Q4X1 31 ATV660C45Q4X1 31 ATV660C45T4X1 31 ATV660C50Q4X1 31 ATV660C50T4X1 31 ATV660C56Q4X1 31 ATV660C56T4X1 31 ATV660C63Q4X1 31 ATV660C63T4X1 31 ATV660C71Q4X1 31 ATV660C71T4X1 31 ATV680C40Q4X1 31 ATV680C40T4X1 31 ATV680C11T4X1 31 ATV680C13Q4X1 31 ATV680C13T4X1 31 ATV680C16Q4X1 31 ATV680C16T4X1 31 ATV680C20Q4X1 31 ATV680C20T4X1 31 ATV680C25Q4X1 31 ATV680C25T4X1 31 ATV680C31Q4X1 31 ATV680C31T4X1 31 ATV680C35Q4X1 31 ATV680C40Q4X1 31 ATV680C40T4X1 31 ATV680C45Q4X1 31 ATV680C45T4X1 31 ATV680C50Q4X1 31 ATV680C50T4X1 31 ATV680C56Q4X1 31 ATV680C56T4X1 31 ATV680C63Q4X1 31 ATV680C63T4X1 31 ATV680C71Q4X1 31 ATV680C71T4X1 31 ATV680C80Q4X1 31 ATV680C80T4X1 31 ATV6A0C11N6 31 ATV6A0C11Q4 31 ATV6A0C11Q6 31 ATV6A0C11R4 31 ATV6A0C11S6 31 ATV6A0C11T4 31 ATV6A0C11T6 31 ATV6A0C13N6 31 ATV6A0C13Q4 31 ATV6A0C13Q6 31 ATV6A0C13R4 31 ATV6A0C13S6 31 ATV6A0C13T4 31 ATV6A0C13T6 31 ATV6A0C16N6 31 ATV6A0C16Q4 31 ATV6A0C16Q6 31 ATV6A0C16R4 31 ATV6A0C16S6 31 ATV6A0C16T4 31 ATV6A0C16T6 31 ATV6A0C20N6 31 ATV6A0C20Q4 31 ATV6A0C20Q6 31 ATV6A0C20R4 31 ATV6A0C20S6 31 ATV6A0C20T4 31 ATV6A0C20T6 31 ATV6A0C25N6 31 ATV6A0C25Q4 31 ATV6A0C25Q6 31 ATV6A0C25R4 31 ATV6A0C25T4 31 ATV6A0C25T6 31 ATV6A0C31N6 31 ATV6A0C31Q4 31 ATV6A0C31Q6 31 ATV6A0C31R4 31 ATV6A0C31T4 31 ATV6A0C31T6 31 ATV6A0C35Q4 31 ATV6A0C35Q6 31 ATV6A0C35R4 31 ATV6A0C35T4 31 ATV6A0C40N6 31 ATV6A0C40Q4 31 ATV6A0C40Q6 31 ATV6A0C40R4 31 ATV6A0C40T4 31 ATV6A0C40T6 31 ATV6A0C45Q4 31 ATV6A0C45R4 31 ATV6A0C45T4 31 ATV6A0C50N6 31 ATV6A0C50Q4 31 ATV6A0C50Q6 31 ATV6A0C50R4 31 ATV6A0C50T4 31 ATV6A0C50T6 31 ATV6A0C56Q4 31 ATV6A0C56R4 31 ATV6A0C56T4 31 ATV6A0C63N6 31 ATV6A0C63Q4 31 ATV6A0C63Q6 31 ATV6A0C63R4 31 ATV6A0C63T4 31 ATV6A0C63T6 31 ATV6A0C71Q4 31 ATV6A0C71R4 31 ATV6A0C71T4 31 ATV6A0C80N6 31 ATV6A0C80Q4 31 ATV6A0C80Q6 31 ATV6A0C80R4 31 ATV6A0C80T4 31 ATV6A0C80T6 31 ATV6A0M10N6 31 ATV6A0M10Q6 31 ATV6A0M10R4 31 ATV6A0M10T4 31 ATV6A0M10T6 31 ATV6A0M12N6 31 ATV6A0M12Q6 31 ATV6A0M12T6 31 ATV6B0C11N6 31 ATV6B0C11Q4 31 ATV6B0C11Q6 31 ATV6B0C11T4 31 ATV6B0C11T6 31 ATV6B0C13N6 31 ATV6B0C13Q4 31 ATV6B0C13Q6 31 ATV6B0C13T4 31 ATV6B0C13T6 31 ATV6B0C16N6 31 ATV6B0C16Q4 31 ATV6B0C16Q6 31 ATV6B0C16R4 31 ATV6B0C16T4 31 ATV6B0C16T6 31 43 Industrial automation systems EcoStruxure Automation Expert Product reference index Index (continued) ATV6B0C20N6 31 ATV6B0C20Q4 31 ATV6B0C20Q6 31 ATV6B0C20R4 31 ATV6B0C20T4 31 ATV6B0C20T6 31 ATV6B0C25N6 31 ATV6B0C25Q4 31 ATV6B0C25Q6 31 ATV6B0C25R4 31 ATV6B0C25T4 31 ATV6B0C25T6 31 ATV6B0C31N6 31 ATV6B0C31Q4 31 ATV6B0C31Q6 31 ATV6B0C31R4 31 ATV6B0C31T4 31 ATV6B0C31T6 31 ATV6B0C35Q4 31 ATV6B0C35R4 31 ATV6B0C35T4 31 ATV6B0C40N6 31 ATV6B0C40Q4 31 ATV6B0C40Q6 31 ATV6B0C40R4 31 ATV6B0C40T4 31 ATV6B0C40T6 31 ATV6B0C45Q4 31 ATV6B0C45R4 31 ATV6B0C45T4 31 ATV6B0C50N6 31 ATV6B0C50Q4 31 ATV6B0C50Q6 31 ATV6B0C50R4 31 ATV6B0C50T4 31 ATV6B0C50T6 31 ATV6B0C56Q4 31 ATV6B0C56R4 31 ATV6B0C56T4 31 ATV6B0C63N6 31 ATV6B0C63Q4 31 ATV6B0C63Q6 31 ATV6B0C63R4 31 ATV6B0C63T4 31 ATV6B0C63T6 31 ATV6B0C71Q4 31 ATV6B0C71R4 31 ATV6B0C71T4 31 ATV6B0C80N6 31 ATV6B0C80Q4 31 ATV6B0C80Q6 31 ATV6B0C80R4 31 ATV6B0C80T4 31 ATV6B0C80T6 31 ATV6B0M10N6 31 ATV6B0M10Q4 31 ATV6B0M10Q6 31 ATV6B0M10R4 31 ATV6B0M10T4 31 ATV6B0M10T6 31 ATV6B0M12N6 31 ATV6B0M12Q6 31 ATV6B0M12T6 31 ATV6L0C13Q4 31 ATV6L0C13R4 31 ATV6L0C13T4 31 ATV6L0C16Q4 31 ATV6L0C16R4 31 ATV6L0C16T4 31 ATV6L0C20N6 31 ATV6L0C20Q4 31 ATV6L0C20R4 31 ATV6L0C20T4 31 ATV6L0C25Q4 31 ATV6L0C25R4 31 ATV6L0C25T4 31 ATV6L0C28N6 31 ATV6L0C28Q6 31 ATV6L0C28T6 31 ATV6L0C31N6 31 ATV6L0C31Q4 31 ATV6L0C31Q6 31 ATV6L0C31R4 31 ATV6L0C31T4 31 ATV6L0C31T6 31 ATV6L0C40N6 31 ATV6L0C40Q4 31 ATV6L0C40Q6 31 ATV6L0C40R4 31 ATV6L0C40T4 31 ATV6L0C40T6 31 ATV6L0C45N6 31 ATV6L0C45Q6 31 ATV6L0C45T6 31 ATV6L0C50Q4 31 ATV6L0C50R4 31 ATV6L0C50T4 31 ATV6L0C56N6 31 ATV6L0C56Q6 31 ATV6L0C56T6 31 ATV6L0C63Q4 31 ATV6L0C63R4 31 ATV6L0C63T4 31 ATV6L0C71N6 31 ATV6L0C71Q6 31 ATV6L0C71T6 31 ATV6L0C80Q4 31 ATV6L0C80R4 31 ATV6L0C80T4 31 ATV6L0C90N6 31 ATV6L0C90Q6 31 ATV6L0C90T6 31 ATV6L0M10Q4 31 ATV6L0M10R4 31 ATV6L0M10T4 31 ATV6L0M11N6 31 ATV6L0M11Q6 31 ATV6L0M11T6 31 ATV6L0M12N6 31 ATV6L0M12Q4 31 ATV6L0M12R4 31 ATV6L0M12T4 31 ATV6L0M12T6 31 ATV6L0M14N6 31 ATV6L0M14Q6 31 ATV6L0M14T6 31 ATV6L0M15Q4 31 ATV6L0M15R4 31 ATV6L0M15T4 31 ATV6L0M16N6 31 ATV6L0M16Q6 31 ATV6L0M16T6 31 ATV6L0M18N6 31 ATV6L0M18Q4 31 ATV6L0M18R4 31 ATV6L0M18T4 31 ATV930C11N4C 31 ATV930C13N4C 31 ATV930C16N4C 31 ATV930C16N4F 31 ATV930C20N4F 31 ATV930C22N4 31 ATV930C22N4C 31 ATV930C25N4C 31 ATV930C25N4F 31 ATV930C31N4C 31 ATV930C31N4F 31 ATV930D11N4 31 ATV930D15N4 31 ATV930D18N4 31 ATV930D22N4 31 ATV930D30N4 31 ATV930D37N4 31 ATV930D45N4 31 ATV930D55N4 31 ATV930D55N4C 31 ATV930D75N4 31 ATV930D75N4C 31 ATV930D90N4 31 ATV930D90N4C 31 ATV930U07N4 31 ATV930U15N4 31 ATV930U22N4 31 ATV930U30N4 31 ATV930U40N4 31 ATV930U55N4 31 ATV930U75N4 31 ATV950C11N4F 31 ATV950C13N4F 31 ATV950C16N4F 31 ATV950C20N4F 31 ATV950C25N4F 31 ATV950C31N4F 31 ATV950D11N4 31 ATV950D11N4E 31 ATV950D15N4 31 ATV950D15N4E 31 ATV950D18N4 31 ATV950D18N4E 31 ATV950D22N4 31 ATV950D22N4E 31 ATV950D30N4 31 ATV950D30N4E 31 ATV950D37N4 31 ATV950D37N4E 31 ATV950D45N4 31 ATV950D45N4E 31 ATV950D55N4 31 ATV950D55N4E 31 ATV950D75N4 31 ATV950D75N4E 31 ATV950D90N4 31 ATV950D90N4E 31 ATV950U07N4 31 ATV950U07N4E 31 ATV950U15N4 31 ATV950U15N4E 31 ATV950U22N4 31 ATV950U22N4E 31 ATV950U30N4 31 ATV950U30N4E 31 ATV950U40N4 31 ATV950U40N4E 31 ATV950U55N4 31 ATV950U55N4E 31 ATV950U75N4 31 ATV950U75N4E 31 ATV960C11T4X1 31 ATV960C13T4X1 31 ATV960C16Q4X1 31 ATV960C16T4X1 31 ATV960C20Q4X1 31 ATV960C20T4X1 31 ATV960C25Q4X1 31 ATV960C25T4X1 31 ATV960C31Q4X1 31 ATV960C31T4X1 31 ATV960C35Q4X1 31 ATV960C35T4X1 31 ATV960C40Q4X1 31 ATV960C45Q4X1 31 ATV960C45T4X1 31 ATV960C50Q4X1 31 ATV960C50T4X1 31 ATV960C56Q4X1 31 ATV960C56T4X1 31 ATV960C63Q4X1 31 ATV960C63T4X1 31 ATV960C71Q4X1 31 ATV960C71T4X1 31 ATV960C80Q4X1 31 ATV960C80T4X1 31 ATV980C11Q4X1 31 ATV980C11T4X1 31 ATV980C13Q4X1 31 ATV980C13T4X1 31 ATV980C16Q4X1 31 ATV980C16T4X1 31 ATV980C20Q4X1 31 ATV980C20T4X1 31 ATV980C25Q4X1 31 ATV980C25T4X1 31 ATV980C31Q4X1 31 ATV980C31T4X1 31 ATV980C35Q4X1 31 ATV980C35T4X1 31 ATV980C40Q4X1 31 ATV980C40T4X1 31 ATV980C45Q4X1 31 ATV980C45T4X1 31 ATV980C50Q4X1 31 ATV980C50T4X1 31 ATV980C56Q4X1 31 ATV980C56T4X1 31 ATV980C63Q4X1 31 ATV980C63T4X1 31 ATV980C71Q4X1 31 ATV980C71T4X1 31 ATV980C80Q4X1 31 ATV980C80T4X1 31 ATV9A0C11N6 31 ATV9A0C11Q4 31 ATV9A0C11Q6 31 ATV9A0C11R4 31 ATV9A0C11T4 31 ATV9A0C11T6 31 ATV9A0C13N6 31 ATV9A0C13Q4 31 ATV9A0C13Q6 31 ATV9A0C13R4 31 ATV9A0C13S6 31 ATV9A0C13T4 31 ATV9A0C13T6 31 ATV9A0C16N6 31 ATV9A0C16Q4 31 ATV9A0C16Q6 31 ATV9A0C16R4 31 ATV9A0C16S6 31 ATV9A0C16T4 31 ATV9A0C16T6 31 ATV9A0C20N6 31 ATV9A0C20Q4 31 ATV9A0C20Q6 31 ATV9A0C20R4 31 ATV9A0C20S6 31 ATV9A0C20T4 31 ATV9A0C20T6 31 ATV9A0C25N6 31 ATV9A0C25Q4 31 ATV9A0C25Q6 31 ATV9A0C25R4 31 ATV9A0C25T4 31 ATV9A0C25T6 31 ATV9A0C31N6 31 ATV9A0C31Q4 31 ATV9A0C31Q6 31 ATV9A0C31R4 31 ATV9A0C31T4 31 ATV9A0C31T6 31 ATV9A0C35Q4 31 ATV9A0C35R4 31 ATV9A0C35T4 31 ATV9A0C40N6 31 ATV9A0C40Q4 31 ATV9A0C40Q6 31 ATV9A0C40R4 31 ATV9A0C40T4 31 ATV9A0C40T6 31 ATV9A0C45Q4 31 ATV9A0C45R4 31 ATV9A0C45T4 31 ATV9A0C50N6 31 ATV9A0C50Q4 31 ATV9A0C50Q6 31 ATV9A0C50R4 31 ATV9A0C50T4 31 ATV9A0C50T6 31 ATV9A0C56Q4 31 ATV9A0C56R4 31 ATV9A0C56T4 31 ATV9A0C63N6 31 ATV9A0C63Q4 31 ATV9A0C63Q6 31 ATV9A0C63R4 31 ATV9A0C63T4 31 ATV9A0C63T6 31 ATV9A0C71Q4 31 ATV9A0C71R4 31 ATV9A0C71T4 31 ATV9A0C80N6 31 ATV9A0C80Q4 31 ATV9A0C80Q6 31 ATV9A0C80R4 31 ATV9A0C80T4 31 ATV9A0C80T6 31 ATV9A0M10N6 31 ATV9A0M10Q6 31 ATV9A0M10R4 31 ATV9A0M10T4 31 ATV9A0M10T6 31 ATV9A0M12N6 31 ATV9A0M12Q6 31 ATV9A0M12T6 31 ATV9B0C11N6 31 ATV9B0C11Q4 31 ATV9B0C11Q6 31 ATV9B0C11R4 31 ATV9B0C11T4 31 ATV9B0C11T6 31 ATV9B0C13N6 31 ATV9B0C13Q4 31 ATV9B0C13Q6 31 ATV9B0C13R4 31 ATV9B0C13T4 31 ATV9B0C13T6 31 ATV9B0C16N6 31 ATV9B0C16Q4 31 ATV9B0C16Q6 31 ATV9B0C16R4 31 ATV9B0C16T4 31 ATV9B0C16T6 31 ATV9B0C20N6 31 ATV9B0C20Q4 31 ATV9B0C20Q6 31 ATV9B0C20R4 31 ATV9B0C20T4 31 ATV9B0C20T6 31 ATV9B0C25N6 31 ATV9B0C25Q4 31 ATV9B0C25Q6 31 ATV9B0C25R4 31 ATV9B0C25T4 31 ATV9B0C25T6 31 ATV9B0C31N6 31 ATV9B0C31Q4 31 ATV9B0C31Q6 31 ATV9B0C31R4 31 ATV9B0C31T4 31 ATV9B0C31T6 31 ATV9B0C35Q4 31 ATV9B0C35R4 31 ATV9B0C35T4 31 ATV9B0C40N6 31 ATV9B0C40Q4 31 ATV9B0C40Q6 31 ATV9B0C40R4 31 ATV9B0C40T4 31 ATV9B0C40T6 31 ATV9B0C45Q4 31 ATV9B0C45R4 31 ATV9B0C45T4 31 ATV9B0C50N6 31 ATV9B0C50Q4 31 ATV9B0C50Q6 31 ATV9B0C50R4 31 ATV9B0C50T4 31 ATV9B0C50T6 31 ATV9B0C56Q4 31 ATV9B0C56R4 31 ATV9B0C56T4 31 ATV9B0C63N6 31 ATV9B0C63Q4 31 ATV9B0C63Q6 31 ATV9B0C63R4 31 ATV9B0C63T4 31 ATV9B0C63T6 31 ATV9B0C71Q4 31 ATV9B0C71R4 31 ATV9B0C71T4 31 ATV9B0C80N6 31 ATV9B0C80Q4 31 ATV9B0C80Q6 31 ATV9B0C80R4 31 ATV9B0C80T4 31 ATV9B0C80T6 31 ATV9B0M10N6 31 ATV9B0M10Q6 31 ATV9B0M10R4 31 ATV9B0M10T4 31 ATV9B0M10T6 31 ATV9B0M12N6 31 ATV9B0M12Q6 31 ATV9B0M12T6 31 ATV9L0C13Q4 31 ATV9L0C13R4 31 ATV9L0C13T4 31 ATV9L0C16Q4 31 ATV9L0C16R4 31 ATV9L0C16T4 31 ATV9L0C20N6 31 ATV9L0C20Q4 31 ATV9L0C20R4 31 ATV9L0C20T4 31 ATV9L0C25Q4 31 ATV9L0C25R4 31 ATV9L0C25T4 31 ATV9L0C28N6 31 ATV9L0C28Q6 31 ATV9L0C28T6 31 ATV9L0C31N6 31 ATV9L0C31Q4 31 ATV9L0C31Q6 31 ATV9L0C31R4 31 ATV9L0C31T4 31 ATV9L0C31T6 31 ATV9L0C40N6 31 ATV9L0C40Q4 31 ATV9L0C40Q6 31 ATV9L0C40R4 31 ATV9L0C40T4 31 ATV9L0C40T6 31 ATV9L0C45N6 31 ATV9L0C45Q6 31 ATV9L0C45T6 31 ATV9L0C50Q4 31 ATV9L0C50R4 31 ATV9L0C50T4 31 ATV9L0C56N6 31 ATV9L0C56Q6 31 ATV9L0C56T6 31 ATV9L0C63Q4 31 ATV9L0C63R4 31 ATV9L0C63T4 31 ATV9L0C71N6 31 ATV9L0C71Q6 31 ATV9L0C71T6 31 ATV9L0C80Q4 31 ATV9L0C80R4 31 ATV9L0C80T4 31 ATV9L0C90N6 31 ATV9L0C90Q6 31 ATV9L0C90T6 31 ATV9L0M10Q4 31 ATV9L0M10R4 31 ATV9L0M10T4 31 ATV9L0M11N6 31 ATV9L0M11Q6 31 ATV9L0M11T6 31 ATV9L0M12N6 31 ATV9L0M12Q4 31 ATV9L0M12R4 31 ATV9L0M12T4 31 ATV9L0M12T6 31 ATV9L0M14N6 31 ATV9L0M14Q6 31 ATV9L0M14T6 31 ATV9L0M15Q4 31 ATV9L0M15R4 31 ATV9L0M15T4 31 ATV9L0M16N6 31 ATV9L0M16Q6 31 ATV9L0M16T6 31 ATV9L0M18N6 31 ATV9L0M18Q4 31 ATV9L0M18R4 31 ATV9L0M18T4 31 ATV9L0M22N6 31 ATV9L0M22Q6 31 ATV9L0M22T6 31 ATV9L0M26N6 31 ATV9L0M26Q6 31 ATV9L0M26T6 31 B BMEAHI0812 28 BMEAHO0412 28 BMECRD0100 34 BMECRD0100C 34 BMED581020 32 BMED581020C 32 BMEXBP0400 28 BMEXBP0400H 28 BMEXBP0602 28 BMEXBP0602H 28 BMEXBP0800 28 BMEXBP0800H 28 BMEXBP1002 28 BMEXBP1002H 28 BMEXBP1200 28 BMEXBP1200H 28 BMXAMI0410 28 BMXAMI0410H 28 BMXAMI0800 28 BMXAMI0810 28 BMXAMI0810H 28 BMXAMM0600 28 BMXAMM0600H 28 BMXAMO0210 28 BMXAMO0210H 28 BMXAMO0410 28 BMXAMO0410H 28 BMXAMO0802 28 BMXART0814 28 BMXART0814H 28 BMXCPS2000 28 BMXCPS2010 28 BMXCPS3020 28 BMXCPS3020H 28 BMXCPS3500 28 BMXCPS3500H 28 BMXCPS3522 28 BMXCPS3540T 28 BMXCPS4002 28 BMXCPS4002S 28 BMXCPS4022 28 BMXDAI0805 28 BMXDAI0814 28 BMXDAI1602 28 BMXDAI1602H 28 BMXDAI1603 28 BMXDAI1603H 28 BMXDAI1604 28 BMXDAI1604H 28 BMXDAO1605 28 BMXDAO1605H 28 BMXDDI1602 28 BMXDDI1602H 28 BMXDDI1603 28 BMXDDI1604T 28 BMXDDI3202K 28 BMXDDI3202K 28 BMXDDI6402K 28 BMXDDM16022 28 BMXDDM16022H 28 BMXDDM16025 28 BMXDDM16025H 28 BMXDDM3202K 28 BMXDDO1602 28 BMXDDO1602H 28 BMXDDO1612 28 BMXDDO1612H 28 BMXDDO3202K 28 BMXDDO6402K 28 BMXDRA0805 28 BMXDRA0805H 28 BMXDRA0815 28 BMXDRA0815H 28 BMXDRA1605 28 BMXDRA1605H 28 BMXEAE0300 28 BMXEAE0300H 28 BMXEHC0200 28 BMXEHC0200H 28 BMXEHC0800 28 BMXEHC0800H 28 BMXNRP0200 28 BMXNRP0201 28 BMXNRP0201C 28 BMXXBC008K 28 BMXXBC015K 28 BMXXBC030K 28 BMXXBC050K 28 BMXXBC120K 28 BMXXBE1000 28 BMXXBE1000H 28 BMXXBE2005 28 BMXXBP0400 28 BMXXBP0400H 28 BMXXBP0600 28 BMXXBP0600H 28 BMXXBP0800 28 BMXXBP0800H 28 BMXXBP1200 28 BMXXBP1200H 28 E EALADP 23 EALALP 23 EALAMP 23 EALAMP 23 EALANP 23 EALBAC 22 EALBAHC 22 EALBATC 22 EALBFC 22 EALBTEP 22 EALBTEP24 22 EALBTS1 22 EALBTS2 22 EALDCP 24 27 EALDHACP 24 27 EALDHAMP 24 27 EALDHAMVP 24 EALDHAXP 24 EALDMP 24 EALDVMP 24 EALDXP 24 EALH1P 24 EALH2P 24 26 EALOMD1 25 EALOMD2 25 EALUAOC 22 H HMIBX1A0NDA 10 HMISTM6400 5 T TCSXCNAMUM3P 39 TM251MDESE 36 TM262L01MDESE8T 37 TM3AGC3 30 TM3AI2H 30 TM3AI2HG 30 TM3AI4 30 TM3AI4G 30 TM3AI8 30 TM3AI8G 30 TM3AM6 30 TM3AM6G 30 TM3AQ2 30 TM3AQ4 30 TM3AQ4G 30 TM3D116 30 TM3DI32K 30 TM3DI8 30 TM3DI8G 30 TM3DM24R 30 TM3DM24RG 30 TM3DM8R 30 TM3DM8RG 30 TM3DQ16R 30 TM3DQ16T 30 TM3DQ16TG 30 TM3DQ16U 30 TM3DQ16UG 30 TM3DQ32UK 30 TM3DQ8R 30 TM3DQ8RG 30 TM3DQ8T 30 TM3DQ8TG 30 TM3DQ8U 30 TM3SAC5R 30 TM3SAC5RG 30 TM3SAF5R 30 TM3SAF5RG 30 TM3SAFL5RG 30 TM3SAK6R 30 TM3SAK6RG 30 TM3TI4 30 TM3TI4G 30 TM3TI8T 30 TM3TI8TG 30 TM3TM3 30 TM3TM3G 30 TM3XHSC202 30 TM3XHSC202G 30 TM3XREC1 30 TM3XTRA1 30 TM3XTYS4 30 V VW3A1104R10 39 VW3A1104R100 39 VW3A1104R30 39 VW3A1104R50 39 VW3A1111 39 VW3A1112 39 VW3A3203 31 VW3A3204 31 VW3A3420 31 VW3A3422 31 VW3A3423 31 VW3A3424 31 VW3A3530D 38 Industrial automation systems EcoStruxure Automation Expert Product reference index Index (continued) mySchneider, your personalized digital experience Create your account Order management > Select Products and Add to Cart > Check for Products' Price and Availability > Order Products with Generic Commercial References Product information > Find a Product Data Sheet and Related Documents > Select Products and Add to Cart > Stay Up to Date on the Status of My Products Support > Get Quicker Answers Thanks to Online Support Training > Access Trainings Dedicated to My Activity Watch the How-to Videos Access an all-in-one customized online experience and benefit from tailored business services, resources, and tools to efficiently support your business operations. → Efficiency: In just a few clicks, find all the information and support you need to get the job done. → Simplicity: Use a single login to access all business services, in one place, available 24/7. You no longer need to log in to multiple platforms. → Personalization: Benefit from content, tools, and business services tailored to your activity, and customize your landing page based on your preferences. Legal information The information provided in this Catalog contains description of Schneider Electric products, solutions and services ("Offer") with technical specifications and technical characteristics of the performance of the corresponding Offer. The content of this document is subject to revision at any time without notice due to continued progress in methodology, design and manufacturing. To the extent permitted by applicable law, no responsibility or liability is assumed by Schneider Electric and its subsidiaries for any type of damages arising out of or in connection with (i) informational content of this Catalog not conforming with or exceeding the technical specifications, or (ii) any error contained in this Catalog, or (iii) any use, decision, act or omission made or taken on basis of or in reliance on any information contained or referred to in this Catalog. SCHNEIDER ELECTRIC MAKES NO WARRANTY OR REPRESENTATION OF ANY KIND, WHETHER EXPRESS OR IMPLIED, AS TO WHETHER THIS CATALOG OR ANY INFORMATION CONTAINED THEREIN SUCH AS PRODUCTS AND SERVICES WILL MEET REQUIREMENTS, EXPECTATIONS OR PURPOSE OF ANY PERSON MAKING USE THEREOF. Schneider Electric brand and any trademarks of Schneider Electric and its subsidiaries referred to in this Catalog are property of Schneider Electric or its subsidiaries. All other brands are trademarks of their respective owners. This Catalog and its content are protected under applicable copyright laws and provided for informative use only. No part of this Catalog may be reproduced or transmitted in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise), for any purpose, without the prior written permission of Schneider Electric. Copyright, intellectual, and all other proprietary rights in the content of this Catalog (including but not limited to software, audio, video, text, and photographs) rests with Schneider Electric or its licensors. All rights in such content not expressly granted herein are reserved. No rights of any kind are licensed or assigned or shall otherwise pass to persons accessing this information. The information provided in this documentation contains general descriptions and/or technical characteristics of the performance of the products contained herein. This documentation is not intended as a substitute for and is not to be used for determining suitability or reliability of these products for specific user applications. It is the duty of any such user or integrator to perform the appropriate and complete risk analysis, evaluation and testing of the products with respect to the relevant specific application or use thereof. Neither Schneider Electric nor any of its affiliates or subsidiaries shall be responsible or liable for misuse of the information contained herein. Design: Schneider Electric Photos: Schneider ElectricLearn more about our products at www.se.comSchneider Electric Industries SAS Head Office 35, rue Joseph Monier - CS 30323 F-92500 Rueil-Malmaison Cedex France DIA3ED2201101EN July 2024 - V8.0 Home Personal Info CPD VA Finance CPD Activities New Application Registration Status fiston tshingombe Home Profile Profile fiston tshingombe Profile Security Change Password Change Email Manage External Authentication TERMS & CONDITIONS Consent for Use of Personal Information By accepting this privacy policy, the user of this website hereby grants the Engineering Council of South Africa (ECSA) permission to use their personal information in the course of its mandate to evaluate applications in accordance with applicable legislation. Safeguarding of Personal Information ECSA endeavours to ensure the confidentiality, loss, misuse, and improper disclosure of personal information it obtains in the course of its business. ECSA does not store banking information such as credit/debit card details. Updating of Personal Information ECSA's personal information is up-to-date by regularly updating their information on this website. Changes to Privacy Policy Any changes to this privacy policy will be published on this website. The user's responsibility is to periodically check this website for any changes. ECSA Information Officer All queries related to the protection and promotion of access to information should be directed to the ECSA Information Officer on (011) 6079500. Your Information I agree to the Terms & Conditions Title Residential Address — First Name House/Unit no: Last Name Street name: E-mail Suburb/Area: Mobile Phone City: Date of Birth Province: Gender Country: Race Group Postal/Area code: RSA Resident? RSA ID Number Waterview Corner Building, 2 Ernest Oppenheimer Avenue, Bruma Lake Office Park, Bruma, 2198, Johannesburg engineer@ecsa.co.za +27116079500 Copyright © 2025. All rights reserved. My Documents Use the View selector to change the type of document you are looking for. Qualification Documents (Portal) Document Category. sort descending Qualification. sort descending PaperTrail DocID URL. sort descending Upload Status . sort ascending Created On. sort descending 2. Certified copies of qualifications * saqa - assessment electrical engineering n diploma https://ecsa.papertrail.co.za/public/file/197370253/Certified qualifications n diploma.PNG Uploaded 10/28/2023 12:14 PM 2. Certified copies of qualifications * saqa - assessment electrical engineering n diploma https://ecsa.papertrail.co.za/public/file/197370254/Certified.jpg Uploaded 10/28/2023 12:16 PM 3. Certified copy of ID/Passport * saqa - assessment electrical engineering n diploma https://ecsa.papertrail.co.za/public/file/197370255/Tshingombe's Resume.pdf Uploaded 10/28/2023 12:19 PM Waterview Corner Building, 2 Ernest Oppenheimer Avenue, Bruma Lake Office Park, Bruma, 2198, Johannesburg engineer@ecsa.co.za +27116079500 CPD Pre-Validated Activities Validation Number. sort descending Provider. sort descending Course Category. sort descending Name . sort ascending Category. sort descending Notional Hours. sort descending Credits Earned. sort descending Nature of Activity. sort descending Discipline. sort descending Sub Discipline. sort descending Valid From. sort descending Valid To. sort descending All Categories All Categories E-Learning All Categories SEMC-BLD-02 IESSA Refresher courses 2-Day Course on Design of High-Rise Buildings: Johannesburg, Cape Town and Durban 20.00 2.00 1/1/2015 12/31/2019 SEMC-ERC-02 IESSA Refresher courses 2-Day Course on Eurocode Design of Concrete Structures: Johannesburg, Cape Town and Durban 20.00 2.00 1/1/2015 12/31/2019 IESSACIEmeetings004/11 Illumination Engineering Society of South Africa Refresher courses CIE Meetings April 2.00 0.20 6/1/2011 5/31/2013 IESSACIEmeetings002/11 Illumination Engineering Society of South Africa Refresher courses CIE Meetings February 2.00 0.20 6/1/2011 5/31/2013 IESSACIEmeetings001/11 Illumination Engineering Society of South Africa Refresher courses CIE Meetings January 2.00 0.20 6/1/2011 5/31/2013 IESSACIEmeetings003/11 Illumination Engineering Society of South Africa Refresher courses CIE Meetings March 2.00 0.20 E-Learning All Categories SAIMM01353 The Southern African Institute of Mining and Metallurgy E-Learning "An overview of the global lithium mining industry" Engineer 1.00 0.10 Engineering Metallurgical 4/30/2020 4/30/2023 AeSSA21-02-22 Mr Frik-Jan Kruger E-Learning "Electrification of Aerospace", presented on 09 June 2021, 17h30 SA time All Categories 2.00 0.20 Engineering Aeronautical 6/1/2021 6/30/2022 UP-T/L_2023 University of Pretoria (Faculty of Engineering: Built Environment and Information Technology) E-Learning "It's not cool to be an engineer with feelings": Diverse staff and student perceptions of academic resilience Engineer 10.00 1.00 Engineering All Disciplines 11/10/2023 11/10/2023 SAIMM01402 The Southern African Institute of Mining and Metallurgy E-Learning "Training, mentoring and knowledge transfer, futureproofing our industry" A virtual panel discussion Engineer 1.00 0.10 Interpersonal Skills All Disciplines 8/18/2020 8/18/2020 WISA2021-00/195 Water Institute of Southern Africa (WISA) E-Learning # WATER 2 ME- INNOVATIONS All Categories 3.00 0.30 Engineering Civil 3/17/2021 3/17/2021 Alerts Information: * mandatory field Top of Form Alert name * Add a title to the alert, this will be used in the subject of the notification. Frequency * Select how often you want to recieve notifications. Bottom of Form Filter options Refine the alert by using one or more of the filter options below. You will not receive a notification if no jobs match the below filter options. Job title Adding a keyword will search for any jobs that contain one or more of specified the keyword/s in the Job title. eg. "Project Manager" or "Millright". Leave blank to include all jobs Locations Filter jobs by one or more locations. Gauteng Mpumalanga Leave blank to include all jobs Categories / functions Filter jobs by one or more category/functions. Accounting, Auditing Trade Marketing Admin, Office Support and Services Electrical Engineering Electromechanical Engineer Construction Engineering/Civil Engineering Chemical Engineering Bio Engineering Fishing and Fish Farming Gardening and Florists Chemical Engineering Leave blank to include all jobs Employment equity Filter jobs by employment equity. Non Employment Equity Employment Equity Unknown status Leave blank to include all jobs Contract Types Filter jobs by one or more contract types. Permanent Fixed Term Contract Temporary Temporary with possibility of being permanent Student job Internship Freelance Franchise Apprenticeship Leave blank to include all jobs My alerts Create and manage your job alerts. Recieve daily/weekly notifications for jobs that match your specific criteria. Note: Please check your spam and trash folders for sent emails. If you still do not recieve the email please contact support. ENGINEERING ELECTRICAL TRADE SENIOR,JUNIOR CADET MINIM , Frequency: Weekly Last notification sent on NEVER Personal details Edit Title Mr Gender Male First name tshingombe Last name tshitadi Ethnicity African Disabled No Is citizen Non South African with a Work Permit Citizenship Congo Republic of the Democratic National ID number Not filled Passport number tircog000910610 Current home location Congo Republic of the Democratic Birth date 1982-10-11 Do you have an unabridged drivers license? No Do you have your own transport? No Email tshingombefiston@gmail.com Mobile number 0725298946 Alternative number Not filled Preferred Job Title engineering electrical Availability 1 Month Willing to relocate? Yes within my country of residence Current salary 250 - 300K Annually Desired salary 150 - 200K Annually Introduction engineering trade Skills Add Adding skills increases your chances of being discovered. Good Panelboard Employment History Please add your full employment history I have no previous work experience Education Please add your qualifications I do not have any formal education Profile Completeness 100% Cv Current: Professional Resume_CV - Atlantic International University tshingombe_pdf.pdf Drop file here or click to browse to change My documents Drop file here or click to browse March 6th at 2:48pm Access-to-HE-Diploma-Specification-Policing-2024-25_pdf.pdf Privacy Statement Disclaimer Terms & Conditions SAQA 30,625 Building a world-class National Qualifications Framework for South Africa, which contributes to the full personal development of lifelong learners SAQA 6 days ago Beware of Bogus Qualifications! SAQA was on the ground at the DHET Bogus Awareness Campaign in Johannesburg, spreading the word about the dangers of fraudulent institutions and unregistered qualifications! Location: Pixley Seme & Lillian Ngoyi Streets Mission: Protect students from scams and help them verify accredited institutions & qualifications through the National Qualific ... See More Photo View on Facebook · Share SAQA 7 days ago Wrapping up our SAQA Blitz Campaign Tour at the Kathu Campus of Northern Cape Rural TVET Colleges!We provided valuable information to students and staff about the advantages of obtaining qualifications registered on the NQF #nqfinformationcentre #nqfthepeople #freedom30 Photo View on Facebook · Share SAQA 1 week ago SAQA's 30-Year International Conference – Save the Date! 7-9 October 2025 Location: Gauteng, details TBAA Global Gathering on Education, Skills, and the Future! Join us for a prestigious international conference as we celebrate 30 years of the South African Qualifications Authority (SAQA). This landmark event will bring together global education leaders, policymakers, industry experts, ... See More Photo View on Facebook · Share SAQA 1 week ago The South African Qualifications Authority (SAQA) and City of Johannesburg participated in the DHET's Bogus Institutions Awareness Campaign at the corner of Rissik and Smit streets. SAQA informed the public about the importance of verifying the registration status of a qualification before enrolling and highlighted the various services it provides #KnowyourNQF #bewareofbogusinstitutions #freedo ... See More Photo View on Facebook · Share Can I do SAQA online? Does SAQA recognise Alison courses? AI Overview Yes, Alison courses are recognized in South Africa and by some South African employers. Some Alison courses have even been provisionally accredited as a SETA NQF Level 3 National Certificate in IT. Explanation Alison is a free online platform that offers courses to help people develop their skills and careers. Many employers recognize Alison certificates and have helped graduates start their careers, switch jobs, or get promotions. Alison's system of accreditation allows employers to verify what someone knows or doesn't know at Certificate or Diploma levels. Employers can take the same tests that employees have taken, or watch employees take the same tests again. You can verify your educational qualifications on the National Learners' Records Database (NLRD) via SAQA VeriSearch. Generative AI is experimental. Learn more South Africa - Alison Blog Discover what thousands of Alison's learners across South Africa already know – that free online courses can empower you with new ... Alison Are alison diplomas accredited in south africa ALISON courses are recognized in South Africa and by South African employers, with some courses even receiving provisional accredi... irp-cdn.multiscreensite.com Verify qualifications | South African Government You can verify your educational qualifications on the National Learners' Records Database (NLRD) via SAQA VeriSearch at the South ... South African Government Accreditation Explained 'Here and Now' Competency Based Testing. The proof of the currency of Alison courses is with the employers who recognise the value... Alison Is Alison a diploma? Alison offers hundreds of free, online diploma programmes for those seeking career or vocational training. Our diplomas are available in a wide variety of industries, including healthcare, technology, and business. What's the Difference Between a Diploma vs a Degree? - Alison Alison https://alison.com › diploma-courses › difference-diplom... What is NQF Level 4 equivalent to matric? National Senior Certificate What is NQF Level 4 Qualification Equivalent to? National Qualifications Framework (NQF) Level 4 corresponds to the National Senior Certificate (NSC), which is achieved upon completing Matric or Grade 12. It is equivalent to the Senior Certificate awarded after passing the Matric exams.29 Jul 2024 What is NQF Level 4? Key to Secondary Education in SA Regenesys https://www.regenesys.net › reginsights › what-is-nqf-lev... Can I get a job with an Alison certificate? AI Overview Yes, you can potentially get a job with an Alison certificate, particularly for entry-level positions or roles where the specific skills gained from the course are highly valued, although it may not guarantee employment on its own; employers often prioritize practical experience alongside the certification, and the recognition of Alison certificates can vary depending on the industry and location. Key points to consider: Skill demonstration: While an Alison certificate alone might not be enough, it can demonstrate your willingness to learn and acquire new skills in a specific area, which employers value. Relevant field: Choose Alison courses aligned with your desired career path to showcase relevant skills to potential employers. Combine with experience: Pair your Alison certificate with practical experience, volunteer work, or other certifications to strengthen your application. Where Alison certificates might be beneficial: Entry-level jobs: For roles where basic skills in a particular area are required, an Alison certificate can be a good starting point. Remote work: Many online-based jobs may consider Alison certifications for digital marketing, customer service, or administrative skills. Upskilling: If you're looking to enhance your existing skillset and demonstrate your commitment to continuous learning, an Alison certificate can be valuable. Generative AI is experimental. Learn more Can You Get A Job with Alison Certificate in South Africa | TikTok 24 Feb 2025 — 23421w ago. missruguru. Natasha | SOLO TRAVELER. Replying to @Lisa #remotework can include. •Digital Marketing. •Onli... TikTok I want to know more about Alison certificates. Does it attract ... 09 Sept 2023 — How good are alison.com courses? Can we add them in our resume? A big Yes! They are definitely helpful and you can def... Quora South Africa - Alison Blog Are Alison Certificates Recognised in South Africa? Yes! Alison is a popular free online skills and career development platform in... Alison Meet the African Businesses Hiring Alison's Graduates - Alison Blog 22 Mar 2024 — Looking for a job in Kenya, Nigeria, South Africa or beyond? Discover how millions of Alison graduates across Africa ha... Alison I just acquired an IT support certificate on Alison. What remote jobs ... 26 Sept 2024 — In my experience, what matters most to employers is whether you have the relevant skills and knowledge for the job, re... Quora Did most people get job with Alison certificates. - Facebook 02 Jan 2025 — Guys you can get Employment with a Alison qualification. Where I work there is a Safety Officer with a Alison certificate... Facebook · Alison- Free online courses Alison Graduates Get Jobs Alison Graduates Get Jobs | Alison Help Center. ... Over 50% of respondents to the Alison Learner and Graduate Survey stated their... Alison Help Center Show more Does an Alison certificate expire? AI Overview No, Alison certificates do not expire. They are lifelong achievements that can be used to highlight your commitment to learning on your CV or LinkedIn. Explanation Alison certificates are always current because employers can challenge them at any time. Alison certificates are compatible with global CPD requirements and can be used to meet CPD requirements. You can verify your Alison certificate by scanning the QR code on your certificate with a QR code scanner on your smartphone or tablet. This will redirect you to the Alison website where your certificate will be verified. Additional information Alison offers free online courses and diplomas. Alison also offers a Premium Monthly subscription that includes additional features and benefits, such as ad-free learning and exclusive monthly discounts. To become an Alison Graduate, you must successfully complete your chosen course and achieve at least 80% in all assessments. Generative AI is experimental. Learn more Alison Accreditation Explained An Alison certificate is always current because it can always be challenged by an employer who wishes to test the certificate ho... Alison How do I add my completed course to LinkedIn? - Alison Help Center Name = Name of course. Issuing Organization = Alison - Free Online Learning. Time period: From = The date you completed the course... Alison Help Center How much does an Alison certificate cost? | Alison Pricing PREMIUM. Premium Monthly is an optional, affordable monthly subscription that unlocks additional features and benefits on Alison. Alison Our Alison Certificates and Diplomas are lifelong achievements that ... 18 Jan 2024 — Our Alison Certificates and Diplomas are lifelong achievements that don't have an expiry date. Perfect for CVs and Link... Instagram · alisonlearning Go Premium with Alison Why upgrade to Premium Monthly? * Monthly discounts that never expire. Get a 10% discount every month that will never expire. You... Alison How do I get my Certificate? - Alison Help Center Validate/verify completed courses The Certificate or Diploma that you purchased from Alison includes a QR Code. Use a QR code scan... Alison Help Center Are Alison courses accredited/recognised? This CPD Certification Service provides recognised independent CPD accreditation compatible with global CPD requirements. This mea... Alison Help Center What's the Difference Between a Diploma vs a Degree? - Alison At Alison, our online diploma programmes are more comprehensive than our certificate programmes, focusing on several subjects

with... Alison Get your Course Certificate - Alison To become an Alison Graduate you must successfully complete course, achieving not less than 80% in all assessments. Al... Alison Legal Name of Skills Development Provider(SDP) Qualification information: Qualification / Curriculum Title SAQA ID NQF Level Credits Curriculum Code An Occupational Qualification consists of three (3) components: Knowledge, Practical and Workplace. By completing this form, the institution should indicate a thorough understanding of how an occupational qualification should be implemented. Please study the relevant qualification document, curriculum document and assessment specification document before completing this form (available on the QCTO website www.qcto.org.za) 1 PROPOSED DURATION FOR THIS QUALIFICATION: FROM (insert date): TO (insert date): 2 MODULES AND FACILITATORS/LECTURERS: (list all relevant modules; extend table as required to include all modules) Knowledge Modules: Hours on time-table: Module Code: Facilitator: (Initials & Surname) Highest Qualification: Type of Industry experience & no. of years: Practical Modules: Hours on time-table: Module Code: Facilitator: (Initials & Surname) Highest Qualification: Type of Industry experience & no. of years: Workplace Modules: Curriculum Code: 2 Confirm whether your institution has all the relevant physical resources for the implementation of this qualification as per curriculum requirements: List of required resources as detailed in the Curriculum: (Extend table as required) Module Name: YES: NO: 3 How would your institution ensure that your staff and learners have a thorough understanding of the occupational qualification, including the final External Integrated Summative Assessment? 4 Explain how your institution would quality assure occupational qualifications offered: Legal Name of Skills Development Provider(SDP) Qualification information: Qualification / Curriculum Title SAQA ID NQF Level Credits Curriculum Code Although the QCTO is not presscriptive in the form or manner of learning material that will be used to implement the curriculum, it is nevertheless still important to indicate how the content will be covered. Bear in mind that learning material for this qualification should be aimed at the implementation of all three components that would best benefit the achievement of all competencies, in order for learners to achieve a Statement of Results. The three components (Knowledge, Practical and Workplace) should not be presented in isolation, but should rather be integrated, and any exercises or applied practicals should be occupationally directed (work tasks). Guidelines on the completion of the below matrix: ☐The name(s) of the learning material or text books to be used should be inserted vertically in the yellow blocks: ☐Complete the table by indicating on what pages the content will be covered for each item in all modules in the curriculum (extend the table as required to include ALL MODULES) For example: Learning Material: Module CODE: Manual(Page/s Number): Learning Guide Page/s Number): Educational Teaching Aids: KNOWLEDGE COMPONENT PRACTICAL COMPONENT WORKPLACE COMPONENT KM-04-KT01 Pp 68-94 Pp 59-72 Pp 59-72 ☐Policy roles and responsibility KM-04-KT03 Pp 62 - 64 ☐Policy roles and responsibility KM-04-KT03 Pp 62 - 64 ☐Policy roles and responsibility KM-04-KT03 Pp 62 - 64 ☐Monitoring & Evaluating Service Delivery KM-04-KT04 Pp 68 - 72 Learning Material: Module CODE: Manual(Page/s Number): Learning Guide Page/s Number): Educational Teaching Aids: KNOWLEDGE COMPONENT PRACTICAL COMPONENT WORKPLACE COMPONENT (may also be in the form of a logbook, covering the competencies required in the workplace) topics Inhox tshingombe fiston 11:34 AM (51 minutes ago) to me Feedback on Security Service Provider Application and Complaint Process Application for Exemption Terms of Section 23(6) Key Points: ☒Applicant Information: oFull Name: Tshingombe Fiston oDate: January 18, 2025, 6:36 PM oContact: Not provided ☒Application Details: oTerms of Section 23(6) of the Private Security Industry Regulation Act 56 of 2001. oDespite Section 23(1) and (2), the authority may register any applicant as a security service provider on good cause shown. oRequirements include applicant's age, training, and clearance of any criminal offenses in the last ten years. Particulars of Appellant: ☐Full Name: Tshingombe Fiston ☒Contact Address: oRefusal to grant exemption. oRefusal to grant exemption. ☒Reasons for Application: oConsultation with Relevant Parties: oConsultation with Relevant Parties: ☒Statutory Mandate: Derived from the Private Security Regulation Act 56 of 2001. ☒Complaint Definition: Dissatisfaction reported to PSIRA regarding the quality of service rendered by a private security service provider. ☒Complaint Handling: Complaints are processed, referred, or dealt with by PSIRA in accordance with the code of conduct and statutory mandate. Security Equipment Definition: ☒Types of Equipment: oAlarm systems, safes, satellite tracking devices. oIntrusion detection, access control, bomb detection, and fire detection devices. oSecurity containers, X-ray, and communication devices. Improper Conduct: ☒Examples: oOperating without registration. oDeploying unregistered security officers. oFailure to meet training and uniform standards. oNon-payment of prescribed wages and allowances. Complaint Resolution: ☒Time Frame: Standard period to finalize any complaint is 30 to 90 days. ☒Common Complaints: Include wage disputes, improper conduct, and training deficiencies. Digital Records: ☒Last Updated: 12-05-2022 ☒Batch Numbers: oBatch 383731: Pending since June 28, 2024. oBatch 383732: Termination pending since June 29, 2024. ☒Contact Information: ☐Contact Number: 0834301100 ☐KM-04-KT01 Pp 68-94 Pp 59-72 ☐Monitoring & Evaluating Service Delivery KM-04-KT04 Pp 62 - 64 ☐Policy roles and responsibility KM-04-KT03 Pp 62 - 64 ☐Monitoring & Evaluating Service Delivery KM-04-KT04 Pp 68 - 72 Learning Material: Module CODE: Manual(Page/s Number): Learning Guide Page/s Number): Educational Teaching Aids: KNOWLEDGE COMPONENT PRACTICAL COMPONENT WORKPLACE COMPONENT (may also be in the form of a logbook, covering the competencies required in the workplace) topics Inhox tshingombe fiston 11:34 AM (51 minutes ago) to me Feedback on Security Service Provider Application and Complaint Process Application for Exemption Terms of Section 23(6) Key Points: ☒Applicant Information: oFull Name: Tshingombe Fiston oDate: January 18, 2025, 6:36 PM oContact: Not provided ☒Application Details: oTerms of Section 23(6) of the Private Security Industry Regulation Act 56 of 2001. oDespite Section 23(1) and (2), the authority may register any applicant as a security service provider on good cause shown. oRequirements include applicant's age, training, and clearance of any criminal offenses in the last ten years. Particulars of Appellant: ☐Full Name: Tshingombe Fiston ☒Contact Address: oRefusal to grant exemption. oRefusal to grant exemption. ☒Reasons for Application: oConsultation with Relevant Parties: oConsultation with Relevant Parties: ☒Statutory Mandate: Derived from the Private Security Regulation Act 56 of 2001. ☒Complaint Definition: Dissatisfaction reported to PSIRA regarding the quality of service rendered by a private security service provider. ☒Complaint Handling: Complaints are processed, referred, or dealt with by PSIRA in accordance with the code of conduct and statutory mandate. Security Equipment Definition: ☒Types of Equipment: oAlarm systems, safes, satellite tracking devices. oIntrusion detection, access control, bomb detection, and fire detection devices. oSecurity containers, X-ray, and communication devices. Improper Conduct: ☒Examples: oOperating without registration. oDeploying unregistered security officers. oFailure to meet training and uniform standards. oNon-payment of prescribed wages and allowances. Recommendations ☐Continued Education: Importance of continuing education and skill transfer in various industries. ☐Practical Training: Emphasis on practical training and on-the-job experience to ensure comprehensive skill development. ☐Feedback: Detailed and constructive feedback provided to improve future submissions and ensure alignment with ISC2 standards. Conclusion Thank you for submitting feedback to ISC2 Security Congress 2025. Your detailed insights and recommendations are highly valued and will contribute to the ongoing improvement of our processes and programs. We look forward to your continued participation and engagement in ISC2 events. Virus-free.www.avast.com tshingombe fiston 11:46 AM (38 minutes ago) Virus-free.www.avast.com tshingombe fiston 11:50 AM (34 minutes ago) to me ISC2 Security Congress 2025: Call for Presentations Your Feedback Submission Details ☒Date Submitted: Jan 18, 2025 ☒Submission Type: Call for Papers Proposals Presentation Proposal Status ☒Status: Complete ☐Presentation Proposal ID: [Not provided] Speaker Information ☒Speaker Name: Tshingombe Fiston ☒Role: Project Lead ☒Prefeuss to generate [Not provided] Feedback Content Overview of Topics Submitted Application for Exemption Terms of Section 23(1) and (2), the authority may register any applicant as a security service provider on good cause shown. ☒Applicant Requirements: Includes age, training, and clearance of any criminal offenses in the last ten years. Complaints Management Process ☒Statutory Mandate: Derived from the Private Security Regulation Act 56 of 2001. ☐Complaint Definition: Dissatisfaction reported to PSIRA regarding the quality of service rendered by a private security service provider. ☐Complaint Handling: Complaints are processed, referred, or dealt with by PSIRA in accordance with the code of conduct and statutory mandate. Security Equipment Definition ☐Types of Equipment: oAlarm systems, safes, satellite tracking devices. oIntrusion detection, access control, bomb detection, and fire detection devices. oSecurity containers, X-ray, and communication devices. Improper Conduct ☐Examples: oOperating without registration. oDeploying unregistered security officers. oFailure to meet training and uniform standards. oNon-payment of prescribed wages and allowances. Recommendations ☐Continued Education: Importance of continuing education and skill transfer in various industries. ☐Practical Training: Emphasis on practical training and on-the-job experience to ensure comprehensive skill development. ☐Feedback: Detailed and constructive feedback provided to improve future submissions and ensure alignment with ISC2 standards. Conclusion Thank you for submitting feedback to ISC2 Security Congress 2025. Your detailed insights and recommendations are highly valued and will contribute to the ongoing improvement of our processes and programs. We look forward to your continued participation and engagement in ISC2 events. Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 1 of 18 Cookies We use some essential cookies to make our website work. We'd like to set additional cookies so we can remember your preferences and understand how you use our site. You can manage your preferences and cookie settings at any time by clicking on "Customise Cookies" below. For more information on how we use cookies, please see our Cookies notice. Title Ms Accept cookies Close Progress Review Review Back Review Review Surname tshitadi Your details Your details First name tshingombe Company name Email address Phone number 0725298946 Your request Your details Your request Review Change tshingombefiston@gmail.com Change Reject cookies Sorry, there was a technical problem. Request an intellectual property (IP) licence Request an intellectual property (IP) licence Cookie settings Your cookie preferences have been saved. You can update your cookie preferences here. You can update your cookie preferences here. You can update your cookie preferences here

power load any time regardless ,switch units fits ,UB2,size plastt box ,, switch itself battery operated and switch low device if about ,80mA,12v .. :how it wot:block regulated 12 volte power , internal circuit plus unregulated,17C ,DC power virtual contact ,which are normal close ,open when detector Sens movemt. Contact unit also connected ,12 line detector contact open R1,and it's output switch low ,this action issued set reset ,flip -floo ,normalt resting .. Switches intu set state Q high used a transistor driver circuit energy relay ,power switch 239 AC outlet and loads, at same ,sR flip flop switch to A Output multi stage remove reset counting pulse from simple clock oscillator ,which run 0,9374 the reason odd frequently clear , the binary counter has 14 stage but make only from internal flip flop 4 to 10 (04-19)and 12 to 14 (012-014) we rotary switch S2 to select one 10 output ,si rotor of S2 kept until the selected counter output switch This happens a soon counter has received the appropriate number of clock pulses,eigth in case 04,16for O5for32,for0664,for 07 switch high after 8192 pulse been counter ,selected counter switch low situation coupled via capacity c1, resistor R# inverses I..-main connector ,three connector ,iex green wire , yellow main wire ,T1 longer ,same wire 160mm , outlet socket .. - insulating shield ,two outlet socket insulation material pvx , -final assembly: step the two plug into socket make noctch , completed box ,, -Pir : testing or adjust.. In used .. -parts list trigger main switch, PC board code available service size 147mm×69mm 1)ub2-size plastt box ,197mm×113mm×63mm 1)PIR sensor 2)heatsink ,19mm,square t o-220 type , 1pushbutton switch spst (S1) 1 rotary switch,1-pole ,12 position (S2) Point knob with removable pointer insert . ,1)6- pin Rj12 socket ,PC board MTG (con1)or ,3way PC board mounting termi block 1) 14- pin Dik ic socket ,for I 1 16 pin Dik ic socket for , 1) power transformer ,12,6v/2va,2851 type 1)29A mains rated relay ,chassis MTG (RLy1) 1)IEC main plug , panel mounting 2(mains sicker flush mounted 4 main socket ,flusg ,15 mm long ,M3 tapped,. nylon M3 machine screw ,10mm long csk head ,N3 machine ,6mn,long pan ,solder lug ,,nylon cable tie 100m ,25 mm length ,6 mm diamt heatsgrink tubing , -semiconductors: quad scmit band ic1,4093B,,4069 binaicounyer,12 regulatory,PnP transit,led green silicon ,, - capacitor, : resist -capacityi -explanation: Project a plethora of , together with the pic programming , -PIC training course. , training development course enhanced ,pic programme module,-bool expirmenting . Experimenting with PIC microcontroller,this book introduces pic programming , jumping straight in with four easy knowledge 8 binary. Explanation logic - digital logic , circuit basic building digital circuit and system . -possible , switch and lamp logic , -lofic gate with inverted output ,, Y=A+B Y=A.B Inverter ,,y=/X.. And gate ,,or gate ,,and gate ,,nor gate. ,exclusive ,incluve gate.-Bistables ..D type bistable , D-typpe bistable,,j-k bistable .. -pratical logic circuit.. -build the circuit wizard way : opening to gates , gate number Intruder alarm: real life application of simple logic intruder alarm push to break , advance... - ripple counter.. -investigate : a block schematic diagram logic syst ,the system is designed to alert the flight crew visible and audio warning ,door switch logic signal respective door logic 0,when closed warning indicator active low requirements logic 0,to produce a visible audio ,study the circuit carefully and then see if you .. 1.what logic level appears at point of door closed ,wath logic level appears x,y,z ,,wath level appears point x,y nose door open other closed .. - circuit surgery : collector feedback theory /bias ,, A=So/Sai,, feed factor,,loop gain ,,Sf°BSo Sai=Sin-beta So -So+beta So=ASin .. AcL=So/Sin=A/(1+beta+A 14. Files system. Record academic and certificate diploma, 1.Pocket number. Implementation work Data right,met investigation: Project : drawing : Career project : theory circuit Schematic Experimental : workshop workplace school class pratical career guidance National trade examination :theoretical and practical ,n diploma 18month Memo tech , Project drawing: interpretation -Mathematics graphic draw :project Line point - Electrical trade theory draw labell: Circuit component make: Resistor cell,baterrie ,AC DC circuit current,lighting washing machine , transmission generation AC inspection -insustrial electronics draw labell Circuit component make: -engineering science Graphic and circuit .. - grade total career ,staff theory learn Pratical exam test trade assessment Engineering electrical. -fault find diagram schematical . Relay -installes rules ,circuit diagram, -lofic system -control system : -15 .experimental,.projects pratical trade framework qualifications marks : certificate diploma 6 month semmester trade.. Trade theory -pratice frame work Component frame ,electrical and electronics Drawing : make circuit tools process make circuit framework Trade pratical engineering:level5,6,7 Process Design Designation unity| ,component| ,tool trade| -male tool pincil draw Make, resistor ,condensator charger circuit tools make drawing . -makee installation lighting way switch : -makee transmission ,generation ,drawing ..design. 3.experimental :project drawing City power Eskom advanced career Drawing workshop and workplace , Library on line project On line. Power engineering,advanced Scheneider,Eaton breaker design -drawing diagrams city : Metering circuit: design Installation city transmission generat drawing schematic: Installation: -drawing interpretation: discovery electronics Drawing make: installation security alarm ,police alarm design intelligence robot circuit timer 555.. Computer electr -4. implementation integration system . Guidelines guidence pratical school Microsoft project azure ..GitHub ,visual studio gith lab Work item : epic item project repository project issue project run project code source readme licence,IP drawing circuit 15.1 Trademarks T Blaser tableaux Met career police tpm , counter terrism , Engineering systems:met block mark TMP circuit maintenance meeting break Data right .. Cell phone: IP licence book rwiten integration : met career detective ,counter flip flop ,electronics ,CCTV circuit right , cameras phographic right lens zoom circuit , repaired center cellphone city vs transmission Telecomm office vs Microsoft office vs circuit power vs installation electrique compagny police data certificate copy license copy private police ,,policy city power Eskom policy claim drawing design power cost economic load ,outage circuit . Total ,pratical , policy claim vs claim alarm maintenance total career , Security safety claim nated counter terro record irregularity phase circuit complain circuit implementation: -total framework policy vs police record LDR framew not meeting vs Terri counter irregularity vs Total grand :grand council department energy Eskom policy ,city power policy terro counter emet. Irregularity mining company trade mark , telecommunication claim vs customer trade marks compone maint Tom . -total grand met tblazer Salesforce energy claud metering energy co circuit incidence force sale policy -data right energy metery claim. Vs alarm relay delay dimer switch. Microsoft project azure blue defender Regulatory factor ,limited Freq , energy cost. Bill cost energy Intergration circuit switch. Record total Physical meeting .. script inspection 16..Experience pratical: www elektor .con, Test book Order booking :200rand ,,4eu - microcontrol analogue audio , digital,test measurement. -Pratical: quick to implement reusable multi plat form , fts. -sub long term weather logger . - ATM,18 compass. -j2B universal MMI module using ,arms cortex .. - FT232 ,USB Serie bridges/BOB Chip kit first Arduino compatible ,23 bit microller development platform,design manufacture. -Parallax : li - ion power pack charger -reflow mate : Supply voltage: 230V/50HZ only Power : 3500w Weight: approx ,29kg Dimensions: 620×245×520mm (w×H×D) Heating method: combined IR radiation and hot air . 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 5 of 18 Operation: directly using menu buttons and LCD remotely using PC software and USB connection. -menu language : -temlerature range ;25 to 300°C - Maximum PCB size :400×285mm -temperature sensor : 2 internal , Optimal temperature distribution thank to IR lamps - Drawer opens automatically et end of soldering , - Glass open automatically at end soldering process - interactive commander for data transfer Command | action h =help. | Print available command ____ -Current drawn by entire system at ,3,3 V CPU frequency| sleep mode | current drawn 8Mhz. |Non. | 5.8mA ____ Fuse settings ATmega 88 Fuse | Ext| OxF9| 8MHZ intern oscill (divided hence cpu clock is 1Mhz-$____ -weathet logger operates supply voltage of nomminal 3,3v power over USB ,is available 17 ,VCC of BOB ,FT232R serial -to-usb converter module for stand alone operation unit power via BT ,, supply voltage between ,3,5v and 30,V regulator ic3 diode detector again accidental reverse polarity connection important employees reduced measure to maximise battery life in stand ,alone operation microcontrol is responsible cincentre measure effort circuit ,3,3 V under various conditions is shown , alkalt or NIMH ,AA cell , 4,5 v or 3,6 v nominal capacity of between ,2Ah and 3Ah ..record data for least 1000hours instead of three AA cell free the employee single ,Li - ion Lipo cell supplies ,3,6 or 3,7 ,, on power saving measure is to carry , 100second ,, measure system draws extra about ,2,5 mA ,,120 ms ,when taking reading in between ,10ms corresponding to the 1hz interrupt the device is from ,power save mode 59 second ,I/o clock micro controller order need to be count the pulse in order , CPU.. Result disping result Test measurement: HH10D humidity sensor module feature . Re Swegethttps://GitHub .com/milkmist)mist rewmaster tools / filter m. Bios serial received firmware download request from the device. Flyerm uploading Kerbal (83475 bytes Upload completed (9,5kb/s. Booting the device Done Hello - the pattern obtained after numerous iteration of the command pixel [I]=y*y* x>>5.. Testing in development board ,,use serial port to upload application ,,serve a console for displaying the message sent to print f +) the Boras fitted with a ,3,3 serial port ,located between the ethernet and VGA connector ,pin marked ,board received the data marke tx is used by the board for transmission the GND is obviously ground ,3V3 is a 3.3 V power rail serial long use 3.3 level (not 5v or RS -232) or the combined devdlop - organisation display of the measurements results .. -CMOS compass module: board .kmz 51 chip ,the resistance variation in resistance cause voltage variation which is amplified,LMC 6036 ,sensor electronics magnetic heading us calculated micontroller bus ,corrected module positions ,pin 7 ,AC power grid in him parameter story EEPROJ - orienteering ,4 load firmware power manufacture ,want to recover the module function bearing send following by modulating.. Wiring block - digital communications with the robot electronics cmps module Graphical representation of the compass point -circuit diagram the construction file eagle files component list software Keypad : consist 12switcges ,4 to the left of the display ,4 right , rotary encoder switch encode build push button three encoder space ,9 encoder build in button 27 button ,a5×6 Matrix need connect key I/o scane 4 key free way , function available some function make ,use diode avoided problem phantom key several press ,a situation turning the diodes package .. Different variations on the 2×@6 LCD ,key swiy offset .main function resistor R38,to R 44 board turned using button S1,s8,s12 key fitting , resistor provide. ,turn key circuit by battery function asymmetric matrix line have limiting resistor (15-R25) is final circuit .. - display: board offers possibility of fitting ,2 line by 16 character (2×16) display ,4 line by 29 (4×29) ,,by 16 character connection ,5v power ..R ,36 ,R 41 is necessary T relay ,R1 ,120package . -Powering : the board main rail (V+) is 5v microcontrol itself ,3.3 derive,3 ,, are directly connecting the display available on transistor (piooo,6,,Pio 2,8. Etc pad k1 and k2 ..signal -construction: - implementation : board - twitter message local area network LAN wireless configt.dialog - communication on the dso board. Detec signal the ratio signal generator DSP ,101dv,and this ,n level of ,94 db application peak to peak with sinuskidaj ,0,53 to 0,59 time supply average Test measurement: Component list Resistor :.R1=220kohm To R5 -capacitors : C1=4,7uf ,63 radial to C7=470nf. - semiconductor: D1,D2=BAT42, T1=BS170. IC1= Ic2=ATMEG,, Miscellaneous:.S1,S2,S3=6mm switch ,PCB mount S4= single -pole switch X1=32,768khz quartz crystal LCD 1=DOG @62w.. Mod 1=BoB .. Mod2= humidity sensor HH10D K1=6-pin(2×3) pibheader option iso interface -20-way socket strips SIL for LCD1 ,, 18 -way(2×9) socket for mod @.ic socket for Ic1(8-eay and ic2 (28 -eay ,PCB hi Settings and function button S1 to S3 Print circuit board. Humidy sensitive used transducer elements frequency 6khz to 7khz measured AT mega ,value with calibration par ameyer again stored series module frequently counting the output pulses module over second ,the 16 -bit counter timer , capacity 64 kbyte,,stored,record .. -soffward : firmware for the microcontroller is written in C complied using .. Program in weather station,LCD to control display .... - construction: double site circuit board diagrams components mounted in board ,socket solder components,fused iso connector ,k1, programmation job ,program used sensor module serial to USB module , switch ,S4 position to select external power ,3,3 - operationel ,: treer button (S1,S2,and S3:,S1 cycle variouse Setting ---- ________________ C28=C26/(4Q.Q×(1+Ao)),. R24=2Q/2(wo×C26) R25=(1+So)×R24, R23=(2+So)×R24/So If ,A=0,7071 and So=,these formulas sin plify to , C28=C26/4 R24=1,4142/wo.c26) R23=R25=2×R25.... ________________________________ Basemodu ---- Lab testing ..prototype audio convert implementation: Component list -Resistor= R1=330 ohm R2=680 ohm R3= 470 ohm Capacitor C1=100nf Inductor: tri ,home -semiconductors Led = standard led yellow - miscellaneous, cinch so let ,solder pins ,USB audio - circuit : circuitry design ,signal pin @, coupled resistor impedat former signal (0,5vand 75ohm) coupling transformer provide galvanized cover upper frequently transfo limited couplings toroidaj core material suitable signaj ,50Mhz .. Construction: PCB -- - schemat diagram of the flasher - Circuit the time integration module Base e two operational amplifier ,A1 and A2 ,- ,non + input and output,varyyng voltage V1(t) is applied A2 driver integrato ,R c and A2 ,Rc stage ,add resist -- Light sensor : With twilight detect: sensiu circuit 9vdc. to .15 VDC..ligth room circuit generate ,lm257 ,R1 and R2,,voltage dived ,,R3 and R 1 circuit , Ooamp ic1 wired buffer voltage LDR suitable R2,voltage pin IC,,,IC1,,, ic2,0 other ,,22kohn R,10two comparators ,ic2and ic 2b compare income p1and p2,0thar output R 90,be ause ,, determine dark ,ic2. and I 2.. -explanation teach ,in A broad based introduction to electronics: digital to analogue and to digital conversion: electronics studies school college UK ,include byec level 2 award electronics diploma in engineering level 2 experienc - e read ,teach teach learn experience test electronics circuit Learn : - beam break flash trigger ,build necessary time delay photo flash response IE -Parts list active loop antenna : - @ PC board code 813 (ant loop) 31mm × 94,mm - @ PC board code 814 (rad loop) 58mm×48mm -@weatherproof plastic box ,eg 130×54×83mm plastics box -@8-pin IC socket - semiconductor: 1BA4560 dual op amp (IC@ 1 k8L08 or 78K10 voltage regulator. 2KDV ,149 varicao diode (D1,D2) -capacitors -3)100uf ,16v electrolyte 5,) 15 nf disc ceramic. -Resistor (0,#5w, 5%) ..micelanot ____ Beam - break flash trigger.: the infrared beam is generated by led1 to led3 and picked up by phodetector diode ,PD2,,op amp ic@ b function as current ti voltage ,while I 1 is wired as non inverting amplifier the latter derives transistor A mosef briefly sait h trigger outbut when the or is interrut . -circuit details: Power isderiver battery in detector unit IRv beam from source unity OD ,3,5 mm jack plug con@ mate ,, detector unit IRv source unit ,IR pgotodetector diode ,is connector diode ground and the inventing input ,out site,,+1,7 v ,and +4,0v ,IR ligth is falling on OD@ dark , basically ,#2kohm ,,2,7kohn ,,220uf ,, Qrin writing amplifier ,, s -Switching the triggers output: Q1 switched when IR beam falls on PD1 collector voltage is normally,beam interrupted ,mosef .. -parts list : IR source unit : *1 PC board code 808 ,57×26mm 1)UBS size box ,8#mm×53mm×31mm 46mm long untapped spacer ,4 M3,×13mm screw ,counter sink head nylon cable tie ,75mm long 12m length ,8cable 23,5 mm ,monk jack plug cable type , - 35mm IR ,led (led @ to led 3 ,1)820 ohm -detctor unit : 1) PC board ,code ,size ,,122mm×58mm 2UB3-size box ,129mm,×68mm×44 mm 1)SPDT mini toggle switch ,s@ @)PC mounty ,,3,5 mm stereo jack,socket ,, - PC mount ,15 mm tapped spaced ,8 M3 ,6 mm machine screws pan head - 21 mm PC board terminal pin,, 19v ,,battery clip lead 1)8-pin Dik ,,IC socket .. 1)30mmm length of ,13 mm to ,,15 mm length of ,12 mm to ,15 mm diameter black pvx conduit or brass tubing .. -1 piece of ,IRv- transparent red film ,approx snap connector or , 1×4- way ,AA cell holder . 1×2 way ,AA cell holder - semiconductors: dual op amp (ic1) 1Bc33,nob transistor ,Q1,IR pgotodetector, - capacitor : - detector board final assembly n: construction v -cinverting scanners for ,VHF/UHF discrimination tap socket ,the basic setup for received ,159 MHz signsk ,,.. - PC board is secured to black the lid M3 ×25 mm tapped keypads pluggi into machine socket .. -precision resistor: -Lcd module: remaining components installer .. -- - digital insulation meter : 1) PC board ,code (main /dis)109mm×84mm 1)PC board code 859 (dc-dc con),70mm×51mm Ub1- size plastic box ,157mm×95mm,53mm 1)LCD modut,2 line ,16 character with back ligthning. 1 ferrite pot core pair ,26 diameter enameled copper wire , 1) 100mm ,lengtt ,o,7 mm diameter enameled copper 1)8m length of ,0,7mm diameter enameled copper wire 1)100 mm length of ,0,7mm diameter tinned copper 1)10×AA battery holder. 0,7 mm diameter pinned copt 1)2- pole rotart switch ,PC board mounting ,wit 16 mm,S1 1)SPDT mini toggle switch panel mounting (S3,S3) @ Min Dil relay ,spt switch p with 5v ,2) binding post ,Bana jack (1 red ,1 black . 24 mm solder lug.. 1) ,16 -pin lengi of Sik socket strips 1) 18 pin IC , socket ,4(25 mm ,m$ tapped metal spacers Block diagram of the ,16 ,bit digital potential the desired out voltage is entered via keypad and microcontrol IC 2 the correct binary number to drive the ,16 relays in the ,R/R ladder networks - arena loop , Experience trade mark , engineering science career ,motoring vehicle,power machine , engineering,trader Compagny,Transnet motoring career , ford career Engineering system and Toyota , nated ,, Magazine collection motoring reviews -rwiten oral relate : Specifications : - 1.engine: -cylinder : four ,in line transverse - fuel supply : electronics multi point ,injector -bore /stroke : 81,0/96,3mm to 87cm -cubic capacity : 1799 cm cube -compressiin ratio : 10,5 to 1 -valce gear : s-o-h-c ,valve per cylinder , variable valve timing -ignition :five -2Engine output: -Max power iso(kW)103 -power peak (r/Min)6300 3transmission: Forward speed -low gear: ,3 ,142 to 1. -2end gear :1,869to 1 -3rd gear : 1,235to 1 4th gear : 0,948 to # Top gear : 0,727 to 2 - reverse gears :3,307 to 1 - final drive : 4,294 to # Drive wheels. : front -wheels and type - road wheels : 16×6,5j alloy Tyre make brigestonr turazan , Tyre size : 205/55,R 26 92v Type pressure front : 220 kpa Type pressure rear : 220 kpa - spare : full ,size disc 5.brakes: Front : 262 ventilated disc Rear : 262 solid disc Hydraulic : ABS , with end and bas. - street : Type : rack and pinion hydraulic ,speed sensitive power assist -lock to lock : 2,7 turns - turning circle : 11,6 metres -suspensiin : Front mac person strut ,lower wisthbor e gas filled dampers anti ,roll bar multi coil gas rear - capacities : Seating: 4/5 Fuel tank : 50litres Boot space. : 304 dm 3: Utily space :928 .DM cube - warranty and service intervals :. 3 years /1000.000 km warranty. 5 years /100.000km service plan Service every 15000km: Honda civic 1,8 Vxi; Volkswagen Jetta ,1,6 Comfortline ,ford focused ,2,0 trend ,, Toyota corrola ,180i Test claim t 203km/h top ,speed and acceleration to 100km/h in ,,9,44 second Honda tops at 202 km/h achieve the benchmark sprint in ,9,39 second performance - test data : .Amarok bitid ,4 motion Engine : -Cylinder / capacity : 4/1968 -bore and stroke : 81×91,5mm -compressiin ratio : 26,5 to 2 Fuel supply:common rail Injection - fuel diesel . -max torque : 400nm@1500rpm -max power :120 ke@4000 rpm -transmission: Shift type: 6 - speed manual - first gear : 4810 -second gear :2540 Third gear : 1.590 Fourth gear : 1000 Fifth gear :0,760 Sixth gear : 0,630 Final drive : 4100.reverse : 4.370 Loe-range : 2729 Control 4 WD selection type electron button Wheels : alloys Full-size spare - 2.measurements (mm) -height :1834 -length : 5254 -width : 1944 Wheelbase :3095-fuel consumption: 120 km/h ,,:8,61/km Urban : 9,8/km - calculate range : 688km - performance: 0-100km/h : 20,8 second 100-129 km/h : 4,86 second rpm @ 120km/h : 2100 -recovery point : Front ,,RHS Rear - underbody protect: Transfer case non Fuel tank : plastic guard Rea diff non - odometer 6,248km -load and towing capabilities (kg) Tare : 1848 GVM : 2829 CVM: 4668 Towing capacity ,unbraked : 750 Towing capacity (braked) - brakes : Front. Ventilated disc Rear. : drums ABS ,yes - load capacity (litre) Load box : 2520 - warranties maintenance and service: Warranty : 3year/ 100000km Corrosion ; 6 years Service plan : 3 years / 90000 km Service intervals: 15000 - guard motor ,police maintance Record Guard gold platinum ion Eligibility car ____ 17. Specifications:volswat golf Pricing : Test pricing Standard equipment; controle aluminium - general data : Kerb weight:1541 kg -length:4212 mm-width,excl mirror :1779mm -wheelbase :2578mm -weigh distribution front ,n/a - ground clearance : 132 mm - boot space : 275 litre,,.. -utility space : 1305 litre - coefficient drag CD : 0,34 Seating capacity : 5 Headroom front : 987 mm Headroom rear : 979 mm Hatch lift height : 2017 mm - safety -warenty : 3 - years : 120000km -maintenance service : 5 ,years : 900000km -2Engine: Type layout : 4 cyl transverse turbocharge . - valvetraun : DOHC ,16 ,valve -displacement :1984 cc - bore ,x stroke mm : 82,5×92,8 - compression ratio ,:92,8 -power kW : 188kw,,6000rpm -torque; NM : 350Nm ,,25000,,500rpm - power ,to weigh ratio : 121,8 kW/ tonne - fuel injection : direct petrol inject -recommended fuel : 95 unleaded.. - drivetrain : Transmission : six speed - gear : ration 1st : 2,92 2 end : 1,96 3 Rd : 1,4 4 the :1,03 4th: 1,08 6th : Body frame with .. Brake from : 345mm disc - break rear : 310 mm disc - wheels : alloy :tyre : - steerit : servitronjc - steert ratio : 14,96 - turn lock : e Suspt front : 10,9 m - susoenst front : Subjectivjy base averaged weights out Driver ,gearbox ,steering ,vraj ride handling ,exterior styling ,interior styling sear , ergonomic control ,luggage space , percentage ,price value - Performance: Accelerated: Speed / time 0-60kph / 3,17 sec. 0-80 kph/4,55 sec 0-100kph , :6,27 sec 0-120kph - quarter mil , soeedo calibration ,120 kph ,error ,,116 kph / -3,3% Overtake 60-109kph. / 3,31 sex 80-129/4,24 sex Braking : Average speed to zero 100-0kph / time / distance : 2,77 second /39m. - fuel economy: Real world test route : 72,3km - fyej used : 6,3 litre -our consumption:8,7 litre / 100km urban cycle claimed : 11,2 litre / 100km Co 2 emissions 195 g/ km Fuel tank size : 55 litre - estimated crying Test conditions: test car odinetr : 5396km Reading-temperature:21deg ,c Wind Locay ,test note : -- Car note Hon payment calculator based ,19 percentage deposit: 18.explanation: comparative test : Subaru. Specifications:-2Engine: Cylinder : four horizontally ,opposed Fuel supply: electronics multi - point injections -bore stroke : 99,5/79,0mm -cubic capacity : 2457 cm cube - compression ratio : 10,0 to 1 Valvagear : s-o-h-c bank four valve 2 : engine output ; -max power iso kW. 123 -power peak (r/Min)5600 Red line (r/Min). 6450 Max torque (N.m) 329 -torque peak (r/Min) 4000 3.transmission : Type cvt Low gear : 3,525to # 2end gear. 2,238 to 2 3rd gear. : #,641to 2 4th gear. : 1,194 to 1 5th gear. : 0,850 to 1 Top gear. : 0,850 to 1 -reversr gear. : 2,358 to 2 -final drive : 3,700to 2 -drive wheel : permanent ASD. 4.WHEEls and tyre: - road wheels. : 18×7,5j -types make : Bridgestone -tyre size : 225/45,, R2891 w. -Spare ,tyre and location ,spacy 5: brakes: Front : 294 mm ventilated disc Rear. : 286 m ,solid Hydraulic ,ABS. Breaker assist 6.suspension : Front : mac person struts Rear . Capacities: seating:4/5 Fuel tank : 65 litre Boot /utility space :348 DM.cube - warranty and service intervals: 4 years /100000 km,warranty ,3 years / 63000km maintenance. Test results: Maximum speed (km/h) -true speed. :210 -speedo calibration:60,,80,100,120 -true speed : 54,74,,93,,113 -odometer error :0,9 percent over. *Accelerated,second 0-60. ,5,2# -0-80. , 7,50 0-100. ,14/95 0-120 , 20,74 0-140. , .1km sprint , 32,15 Terminal speed : 264,4km/h - overtaking acceleration: second 40-60. ./ 2,53 60-80/. 3,01 80-100/. 3,65 100-129/. 4,41 - fuel index : Manufacture fig : 9,2 litre /100km Car fuel index :/1 0,92 litre /1000 Estimated tank range : 595 km Taxable CO,2 rating : 214 g/km -braking test : 10 stops from 100km/h measure in second at ,30 second interval on good bitumeise -beat / worst stop : 2,70/2,89 Average of 10 stops rating ,2,79 excell - geardsd speeds ,km/h low gear ; 52 , 60 2 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 6 of 18 Nd gear : 82 ;94 3 Rd. gear. : 11; 128 4th gear : 253 ; 176 5 the gear. ; 299 ; 344. - calculated at engin power , 5600 r/ Min and red line ,6400 r/ Min - performance factor : Power / mass (w/kg) 80 Power / litre (kW/ litre) 50 Power / litre (ks/litre). 93 Torque/ litre (n.m / litre Engine ,,: 1124 Engine rev/ km - mass tested (kg) - test conditions : Altitude : at see level Ambiy temp / barometric press ,22° c / 2020 hPa Test car odometer : 1765 km -150000km warenty and five t ,100000km service Comparative: Test summary class Hyunay test scores,25/29 Mercedes Benz blue efficiency,75/100 Opel Corsa collour - hummer H3 adventure Design and development the TBM ,,700 is singles turboprop engined low wing monoplane aluminium and steel construction the TBN product PT 6 A ,rates at 850 sho (634) ,,522 kW take off and landing cruise flight engin power,859 ,,634 the extra ,,2529 neutical miles (2829) -General characteristics: Crew : 1 or 2 pilots Capacity: 4 to 6 inclus on passenger .cockpit Length : 10,65 m (34 ft 11 in) Wingspan : 12,68 m (42 ft 7 in) Height: 4,36 m (14 ft 3 in Wing area : 18 .m.n (193.7 ft Empty weight : 2132 kg (4699 lb) Max take off weight : 3354 kg (7394 lb) Max playload : 385 kg (849) - performance: Maximum speed : 593 km/h (320 knot ,368 mph) Cruise speed : 467km/h (252 KTS ,290 mph) Range : 2813 km (1519 NM,,1784 miles Service ceiling : 9450 m (31000 ft) Rate of climb : 12,09 m/s (2380 ft / Min Time to climb to 26000ft -- Based . Price : | POA Number of seats and luggage : 2 seat ,34 kg - engine type : Lycoming -fuel burn : 23-30 litre per hour - tank capacity: 136 litre - range and endurance : 2384 km - propeller type and oper: sensenjc -undercarriage: - lead time orders: depend -standard avionics: vrf Panels - Speed |. Size |weigth Cruise:147 KTS| length 6,2m|MTow:794k Stall:38 KTS. | Wing:85 m| empty :460 kg Vine:171kts| height :1,8m| useful: 334 kg -pulk out plan Explanation VIP. Paint protection that actually works approved by major Manufacturing in South vehicle shield .. -bonnet guard , Headlight,front guard,side guard ,,repaired scratches ,stones Chios ,damage ,film removed ,film warranted 5years peeling ,bubbling and cracking -____ Journey|price|engine|power|torque| 27sxt. | Maintenance plan: three years /100000km -fuel tank:78 litre -averagr sales per month -service plan 17..Explanation engine calculation How to calculate bore ,stroke displacement -volymetric efficiency VE=3456×cfm÷CID× RPM,, -Cubic inch displacement=NOC=Noc×SV - head gasket volume: HGV=HGCT×0,785×BORE: PVD=0,7854×Bore×DPD)+)+(VPD-VPB)= piston deck volume - compression ratio CR=1+0,7854×30RE×strokr÷ccv+HGV+PDV. +ISH=HP/16 : fuel system injector size per horse power.. VE: volume office, Cfm: engine air flow rate cubic feet per mine. Cid : engine displacement ,size volume cubic -RPM= engine speed revolution per minute . - NOC: number of cylinder -bore =length -stroke = length -HGV= head gasket volume Hgct : head gasket compressed thickness. PDV:piston deck volume DPV: piston distance Or .. SV= sweet volume . CR= compression ration Ccv: combustion chamber volume Ish = injector size per horse . HP: horse power--________________________ 18.Explanation: engineering science ,stress,unity stress,type stress,unit for strain , elasticity ,hook low, straight, ductile material,young module elasticity.. -explanation : applied thermal engineering engine testing: structure ,explain performance measurement:. - basic parameters: -measuremsnt of speed . - fuel consumption measure -measuremsnt of air consumer -measure of exhaust make -measuremsnt emissions. - measure of brake power : -measuremsnt of friction horse power. - performance of si engin -porformence Calculate speed in evaluation performance development : charge load -bp=2πNT÷60, break,,2πnt/60,, AL ,,N.K/60 -specific output: Specific . Volumetric efficiency n=mass of charge actually scke in÷mass of charge corresponding to the cylinder pond conditions. -relative power air : FR=actual fuel - air motion÷stochiometric fuel -air (bsfc).. - thermal efficiency heat balance .. Brake thermal efficiency:= bo÷ m.f×c -performen e: Heat equivalent break work rejeter to cooling . - heat career for engin .. Heat balance sheet. Input | kW| %| output | kW | % ________________________________ -explanation: construction techniques:. Petition: record -structure ,model aeriplane. section :;. Side : Model assembly details: Covering and finishing. Refinement. -------- -construction note Letter : ..... Materials:-- -letter,|number|name|size. |Masse A. 1. Gear 1/4 , -- Seat,frame,back,fender,back,Fook, healings,front,front axle,wheel,gasttank,rivo.. -- three wheel motorcycle: motor driven car ,, - simplified concrete mensonery planning ,mortar ,concrete = A.P/s - ----------________________________ - explanation study material and fire arm ,ballatisc Gun Typical muzzle energy of fire arm: ________________________________ -fire arm (except |calibre |muzzle energy -air gun .Ek=1/2×v×v(2ft.LBf/7000gr×32163.f.t.t/s.s E=(m×v.v)+ K=450,95(2×32,1930,700)-- -spefication -Calibration:9mm ,para ,40s , -ovarall length : 2184 mm. -barrel length :5 - high : 240mm -weigth:0,81k Construction slide Magazine : 24 round sign front ,GPS -test firing results : -Ammunition : group - factor : -41mm. - hand load :51 mm..note accuracy average.group..fired ,25 mm... --------------------- -artillerie ,AM×30F@ Characteristics service -types : canon automoteur,utilisation Conflicts. -characteristic equipment : 4 home piece piloted longer left : 10,23 mm Larger weight:13;10mm Hight : 3,17 m Mass in combat : 43,5 tonnes blindage ,size ,case lunch.. -- -report installer: - mounting battery replacement step remote: - connection to the fence -connection , configuration -pc board replacement - service condity -Pc board ,F1,Fu ,18 vac fuse.. -Lcd display,18 LCD ,7,2 output in 500ogm Energy out put .500 ohm ,joule -9000v ,zone monitot,1/2 control display,2 max gate - gate and panic button input time gate ,yes - alarm output ,siren output .. - power consumpt under normt operational conditions ,18VA -battery time charge ,24h - solar power operational,60 Ah -wire in a Serie : galvanized : @,2 mm : 5 m optimal.. High voltage ,set point :10,00 volt ,set -- Balance rate installation: item..design draw element ,security access plan. --------- Card access reader mount type technologie. -biometric access reader mount type be specific. -keypad device. -keypad,kepead securt. -card reader with key.. - horn siren - weather proof him - horn ,strong - strobe. - car reader with turn attandance, Tensile,revolving door -traffic arm. -vehicle ,exit device , -smoke detector, -heat detector. -gaz detector, carbon monoxide,electro lock, push button ,camerarwite,camera ,with intercom, - security window scret ,heat detect, -window contact,vibrasic,glass,floor,car drivers,overload,dual tech ,contact saity,wall motion,floor motion, -beam fence distribution, - 19. Explanation : pratical school Disciplinary hearing school . trainings system orientation school career guidence : Experience trade explain: career skill -explanation: safe road usage teacher manual secondary: -explanation the foundation for road : Meaningful maturity,human dignity mordaly depending decisions,making responsible action , identification of criteria, phylosophie of life ,inclucating road safety , various level human , existing in frame of reference,co existing temporary,relation , - explant:the origin of technology and it's implications Forman ,technology and responsibilities ,Sens of responsibility and Education,the task of the school, requirements of the school,road safety and involved in accident, accident according degree ,type of road user accordt to racial group involved , statistics cost alcok poor vision . - explain: traffic training secondai ,content of traffic , traffic situation,those involved,road safety , certain criteria for ,traffic training ,certain requirements , content method for ,youth levels ,abuse among , legislation and low enforcement ,vehicle ,trafft ,element , traffic hours . Trainer methods conversation,self , training, Education orientation, -expt differential teacher road safety education ,basis off teaching from road ,child involved , inequality child different safety Education ,road Education for school undertaking parent school local ,,locak - explanation different road safety education and the secondary: Education concept ,secondary school ,diffet road safety , Education central ,road safety ,road safety situation, road safety orientation,road saft Education road attitude , secondary child personal,goal diffential road safety,road safety matury, psychopedagogie persscpectuve, fundamental pedagogic perspectt ,social pedagogic , didactic , orthopaedic ,irthopedidact, realisation , opportunity and road safety education, The school , secondary child basic ,, - explanation:the methodology of road safety,goal of traffic Education , traffic lesson objective,the learning objectives, problem settings and problem solving , - lesson structure and form.. -explan group course lesson , actually preknowled, actually , unlocked of new , evaluation, group discussion,class arrangements,quality teacher ,skill the teacher and group,how to handle group ,group cohessiob ,criteria for judging the success of .. General methodology guidelines. -chao teaching aid road safety education : Teaching lessons modalities teaching didactic , a schematic presentation of Education , teachings software . Teaching wath look like ,teaching wath , teaching broad ,blackboard ,conograpguc teaching aid ,poster brochure model.. -thw sons box training ground the overhead projector , - the overhead projector film projector . -selecting teaching a lesson ,nature , didactic consideration, -road: safety ,nayv,point of contact in road safety ,few partie , department transformer provincial authority vlocal , evaluation .. -calcul situation traffic possible, criteria,test total traffic situation,different large ,self orientation up him self regards world self discovery evaluation accepted road,lesson telling lesson subject road ,time 35 minute ,lesson objecy explain pedestrian ,setting problem pupil ,stopping ,self realisation , instruction control .. Topics :Lesson objective to explain ,learn objective pupils must knowledge the application legislation and must able to mention aspects which ensures safe , pedestrian. - explain the problem: LinkedIn up knowledge pupi will be led to the realisation that injuries pedestrian behaviour is not only annoying to other dangerouse during lesson phase new content is gradually unlocked , - scheme consider energetic behaviour on pavement keep try to walk next another , stepping pavement intersection trafficking ligth buses getting out of vehicles. - the course of , actually preknowled the pupils citoyeb Saturday morning ask Unlocked behaviour pointed outcome traffic legislation is explained content , mentioned in problem solving is unlocked b, - explanation : functionalism : practising of acquired insight by mean model or diagram on the black board may explain how the will intersection as an assignment pupils observations and make annoying and effective behaviour of pedestrian.. -explanation defensive driving; road sign ,warning sign ,guidence , regulation sign , traffic bsign ,hand signals ,flag signal ,overhead lane flashing signals, road marking, - explanation: rules of road vehicles : control theory test driving.mirror blind spot ,signsk clutch ,speed control breaking ,gear change ,motorcyy ,board inspection , inspection staring , Explain manouvring test moving running left speed control changing ,incline ,turning speed judgement emergency . - the driving test : light motor vehicle, heavy motor ,the years ,staring procedure ,moving off , inclined ,alley docking ,reversing ,making a left turn ,hand signal , parallel parking ,the road test ligth heaving , light and heady . - changing lanes ,stopping in traffic , stopping parking , turning at intersections, proceedings ,stop traffic sign ,entering a traffic circle, leaving a traffic ,block pedestrian ,level crossing , overtake,entering ,leaving freeway ,overtaking ,on a freeway passing , freeway on Ramp.. - explain test checklist record , faillure manoeuvre point ,exceed time limited 29/18 penalty , roadworthy, violation traffic low , uncontrolled action , dangerous action , collision, 20..Explanation: Management system information: pratical Science motor policy guard - statement of insurt; statement of the administration,vehicle eligibility, important servit,policy commence date, replacement of components,claim procedures,cover provided this policy , components Covered, beneft: classic,bronze silver ,gold, titanium, polyester ,ceramii , additional silucd , transfers it,exclusion form cover ,limit Silver,gold titanium ,limi of indemnity,wear and tear restrictions, consequences damage,cancellatt,jusdiction currency and dispute,fraude ,quality control,insurer rigth after , service history intarion , statutory notice , resolution.. - explanation : road warranty all passenger commercial maximi carrying capacity 200kg , cover the cost service maintenance accident ,petrol engt service relevat as . -displacement interval .petrol diesels electric maximum service run over if 1000km or 30dats occure RMI repair claim , - policy vehiclt schedule still subject to Manufacturing warenty plan motor guard plan. - faillure occuring 39 days . - replace claim process in event of mecanique construction fail occury. - Owen ,policy number , current kilometre ready,partict of clay ,item cause quotation,address vehicle inspected service record invoice submitted with 45 days , benefits ,5 years ,120000km ,18 years ,160009km - description of good stolen property must descrt very accurate bear it in mind invest official searching good , -makee or manufacture ,modej not years ,years of products, serial number ,registration ,engine and chassis ,size ,colour ,completed ,state midst iteb ,charge that change , ____ - 22. explanation: industrial administration management - explain : general framey historical background complexity of management - general princy and groi of management thought. -growth of management the pioneers - outline of managet theory : definition - business orgat: organisation the diviy of managet, -growth of organisations stage growt ,orgabiy chart , organisation rekatu, - organisation problem : corpsratt planint traditional and modern organit theory future reauit , - production marketing and admnistration. - organisat and the manufacturing fynctt stage in production manufacti,organisation of production the manufacturer functions: -:Products the ancillat functions b; maintent production planning and control store keeping purchasit handlit of material. - products the advisory functy : work studye time ,method -production the advisory functions : work study time study methods work study , ergonomic , operational research inspect. -marketing : marketing's organisat: admnistration area ,personek management wage. - growth of industrial relat: trade union unions emply associt collective bargaining and joint negotiation: - personal managent : motivation of management content of a personal policy achievement of harmony of objectiy: - the person's department staff recruitment, the manager . - personnel functionalite organisation if personnel department staff recruitment sciencetif selecti - job evaluation and : wage structure determining the wage structure merited rating personnel problem induction training wage and salaries: - personnel problems: disciplinaire promotion safety labour turnover management by participation personnel statistics ., part four financial management and statisciak .. - financiere management : scope of accounting provist affinaire source of finance. -outline of financial and cost account definition the purpose account , fundamental accounting transit from financial to cost accrost , classification. - of cost controlling cost absorbing factor .cost miscellaneous overhead absorpty , overhead facially .. -cost account system : process casting batch costing hybrids costingststt organisation for labour orgat for material cost organisat for overhead .. - method of casting and control : marginal costing decision . - profit and efficiently and loss measure capital expendy decision . - statistical method : Chart and graph statistics quality control . Designation experimt time Serie published statistic.. - part ,five the industrial environments: The middlege to eight center the industrial revolution from development of large .. - principal development in some ,major : coak iron and steel engineering textile chemical and artift fibre ,scienty research.. - the economic ent:.demands and supply cost of production types of compety resale price maintenat the general economic situation. - general principles of financial and visit low banking and finance trade credibly commerce the merchant bank and issuing house hire finance industi and commercial Indy corporation for industrial negoy instrument. - government and industry: introt devet of govert organisation of control . - necessity for government control : - element of legaj system : the low modern communities source of low common low system Englanders and Wales legal person the idea and property. - general princiy : of contract princt of contract and commercial law ,contract ,tart liability for dangerous premise agent sale good , miscellaneous commercial low matter, - elements of industrial low apprenticeship contract of employment factories act Offit premise ,act social insurance industrial arbitration industrial relations general managent division function .. - explain award bid clause ,price industrial minimum salair ,flow manufacture process lighting tube. Design process: Order ,item price : product case 24. Explain: pratical school regulation and irregularity Vocational guidance theory and practice: -1 vocational guidance , -2 explanation: psychological explanation of occupational trait and factor personality 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 7 of 18 development , social learning ,decision making autonomy, -3 explain sociological explanation of occupational ,choice class gender ethnicity group , opportunity structure an interdisciplinary framework. 4- explain , the interview: philosophy, structure questions talking silence , listening ,non verbal communication information and advice. - 5 , explain traite factor client centred , psychodynamic, behaviours problem silvt , fantasy,the place of counseling in vocational guidance. -6 Career Education: explain objective: structure and occupational information the curriculum evaluation. -7. Test interested questionnaire,self help instrument computer based guide special program - re written career guidence ,total faculty subject total grad time table Admi total grand reason career .-explanation: study of occupational ,self study of occupational. -qualification obtained your present position how college. - how to choose career,: knowledge of occupational finding about occupation , know yourself. -how to apply find employment,way find . -how to apply for work . -how work relationship, introduction, different kind ,your concept relationship , - communication ,danger --explain , psychological test : instrument , mechanical and technical aptitude. -qualification| work do to choose career - occupation | social conduct , relation social . Psychometric -Personality and aptitude profile confitial psychology Name : Interest ,| attitude | verbal reasoning , vocabulary ready completed| factor | personality - test results reported | survey councillors . - profile / v(y) ,, Batteries , ____ -explanation tpm is profitable,direction in production achievement zero breakdown the parko factory. -RPM challenge limits from four devet stage , definition and distinctive features Tom striving for overall equipment effectiveness tomb,defect prevention system ,between , Tero technology and -explain: maximizing equipment effectiveness , equipment used at half effective. - breaks motor stoppages imped automation stop acceleration the deteriore of equipment. - explain preventive maintenance alone cannot eliminate breakdown five counter measure for zero breakdown. - unlicensed operational of automated equipment errors equipment investment, five tpm development. - organising for tpm implementation the twelve step . -step ,announce top management decisions to introduce tpm ,step 2 : launch Education companies. Step 3 : establit create organization's promotion. - established basic Tom police and coak . -formulate master plan for tpm .. Tom , implementation,and stabilzat. Step 6: hold Tom Step 7: improve equipment effectiveness. Step 8 : estabt autonomous , maintence prograyfor operational. -step 8 set up schedule maintenance program for maintenat. Step conduct improve operation and may skills ,step initial development equipment management. Small group. - integration small ,small group goal coincii with goal , - evaluating the maturity of small group acty the functionalite of top many in small group . 25.Total maintenance product,,meeting police ::-- -explanation: director social worker practice theory and skill, - explain social work,an overview. Direct practice domain phylosophie and roles . - overview of the helping process. -explain operationalizing cardinal social work. - relationship building skill community with emphasis and authentic. Verbal following exploring and focusing skill,eliminating counter productive communict patterd multidimenst assessment, - assessing intraperst and environmental system . - assessing family function , forming and assessing therapeutic group,enhancing motivation,with involuntary and ambivat client,negot goal and formulating contract . - change oriented phase ,planing and implementation change oriented strategies. - enhanced client problem solving skills assertiveness. - modifying envit developing resource and planing ,.additive emphasis interpolation confrontation ,managing individual famili and organizat barrier change. -the termination and evaluation phase , Explain : final phase termination and evaluation of code ethics,timing and intensity ,of self disclosure. -A paradigm for respond authentic stimulation client message. -Fuel for authentication response.initiated by practionner. - positive feedback form of authenticity response . - relating assertivei to client saying no and setting limit, - exercise in responding authentication and ,client statement model resnse ,in surface underlying feeling , answer to exercise to discriminate level of emphasize response. - explain: verbal following exploring and focusing skill , maintaining psychopedagogie contact with clients exploring problem. Verbal following furthering response ,paraphrasing response,open and closed end , responding,client statement,seeking concreteness ,modeled response , summarise response analizing verak following skil , - focussing ,a complex skill selecting topics ,exploring topics depth blending open ended ,empgic response maintained focuy.- evaluation used of focussing , response ..to exercise,answer to exercise identify in close and ended response .. -explanation : eliminated counter productive communication patterns: impacts of counter productive communication patterns : eliminating non verbal effecty communicay culture nuance of non verbal ,other inventory of non verbal patter of responding -communication barrier eliminate verbal to effectively,gauging effective response the challenge of learning new skills. - multidimensional assessment, critical role of assessment , -assessment an ongoing process , assessment as product,include strength in assessing,sources of information verbal report.direct observations of non verbal behavt observations interatclient monitoring collateral source of infot. -psychologi test , -computer assisted personal experience based on direct interat. - the importance of self awareness. The multimensionality of assessment. -the problem identify the clarity ecological factory assessing devetneed stress association. -key factor to be addressed. Manifestation of the problem, participate -explanation: source of information verbal report.direct observations of non verbal behaviour, observations interactive.client self monitoring,collateral source of information. - psychological test., computer assisted asssessor personalite expression based on direct interaction. -the importance of self awareness. - the multimensionality,of assessment,the problem identify the clarifying , ecological factory assessing development, participants and system implicated in the problem how participate. , development stage and life transitions. - severity of the problem meaning client to problem. - site of problematic behaviour the temporary context of problematic. - frequency of problematic, possible alcohol, substance. - child maltreatment.and spouse abuse . - client emotional coping effort skill strength and skill of client . - cultural and social class factor questions to be answered assessment other factors . - assessing interpersonal and environmental. -the interaction of multimensionality humans the introper system , biophysical characteristics presentation. -physical health cult factor in social support , assessing use and abuse of , alcohol and drug , effect of abuse alcohol dual diagnosis in , biophysical social , using interview skill to asses possible , alcohol ,using instrument and procedures assessment . -assessing abuse ,use of instrument and procedures ,conveying assessment finaling client.genetic factor psychiatry. -cognitive , perceptual , intellectual judgement , reality testing, cognitive flexible ,value misconceptions, concept, interaction between cognition emotional and behavioural, - emotional functionalite, emotional controls ,range of emotional, appropriate of affect ,assessing effects disorder ,bipolar effective, bipolarity ,assessing social,,- : motivation: precipating event and motivation,in volunteering client ,culture norm , different, determined pattern degree of acculturation , bicultural and mental health .. - fluency with language problem solving , achieved credible, providing immediately benefit attitude ward , environment health and safety factor environment resource universal need identify relevant social , system social support system . - negative social support system assessing reciprocal interactive between individuals , instrument to , environmental need of disabled. - assessing family function the evolution of family system. - system framework for assessing . - family functioning , family home , content process of interaction.. - sequence of interaction employment circulum explanation , assessing problem. - outer boundary internal boundaries and family subsystem family power structure , family decision making , family and range feeling ,gosk , family myth cognitive communication styles of member , - forming and assessing therapeutic group ,classication of group formation of therapeutic,group established group purpose,Agence and practitioners perspective. - established specifications individual group goal.. - conducting preliminary interview. - group composition. -open versus closed group ,size frequently and duration meeting. - voluntary versus involving .. -assesin group process, assessing patterned idify group alliance , group norm value , -enhacing motivation with involved , applying concept from social, initial contracts structure of initial interview.. - using confrontation facilities. - negotiation a problem search bargaining with clients getting mandate off your back .. - exploring self defeat consequences,resolving ambivalence in family creating incentive culture hope , highlights strengths modifying cognitive self . -negatiatinf goal and formulating an rational contract ,purpose of goal ,type of gosk , guidelines for selecting ,process of mutually selecting .. -- -26. labour relations in education . - termination for labour in education - act and bills for labour low in education . - explain: an historical, clarification of concept the development of labour ..- the of exploitation racial discrimination, Explanation: era of advertisement ,the era code termination and cooperation. - development of Education labour relations. -sources of labour , labour relations and the constitution. -the common low and labour legislation for Education. -the rules of natural justice., -the contractor of employment,labour relations act and related labour low. - labour legislation for Education - individual employees relation . -defining employees and employers in education. - employees right of employment in education, - employees right of employment in education , - fundamental right . - duties of educator as employee .-dumie of employees Skill development and Education ,national skills authority ,seta for Education, - learnership in education , - collective labour ,freedom association, organisation right of trade union ,. -collective bargaining in education,collective agreement,managing industrial action strike and lockout. -responsibilty of manager , - procedure during strike ,duties of manager , established and implementation..- fairness in workplace disciplinaire: - substantive and procedural fairness,fair unfair dismissal , progressive disciplinaire , - workplace disciplinaire Education: - incapacity ,poor work performance,defining poor work, procedure incapacity, health injury , definitely health ... 29. Explanation : - Principle of commercial low : Large credit ,agree small intermediary, - explain: size of agret, regulation, concellation of registration of credits b, - registration of definitely counselor credit . - consumer credit policy. - source of the low , statutory low or legislation. - the constitution . -the customer low,judgt of the court ,old authority , foreigners low , case discussion. - the court in republt t constiy court , - the constitution court . The supreme court appeal ,high court officer of superior court duty -officer the supieur court duty process master . - magistrate court . - doctrine of store decision ,Cree case create judg . -application of the doctrine : - interpretation status : the relationship bet the star decision rules the general principles, - court judgement : ration decides . -:the term : low rules ,meaning low rigth, legal subject legal objt, intellectual,private low , protection , servitude bself defense provocation . ,- term of the contract : essential natural and incidentally,condition ,penalty - contract of sole: the our,chosen is entitled to be protected by seller again b,for content , - indemnity insurance. - determinat of the amount payable non indemnity insurance ,value house ,. - relation diffusion form intellectual, - franchising : mediation, arbitration,award Statutory arbitration,source of the low of arbitration ,matter excluded form arbitt ,national cause ,matter relating to ,criminal case ,validity of arbitration agree ,the arbitration agree ,the power of court in relation to arbitration agreement,stay of legal proceeding where there is an arbitration agreement appointment of arbitration,power of power of partie , appointment of arbitration ,power of partie to appoint arbitration to fill , termination of an arbitration , - notice of proceedings partie , summing of witness and recording , evidence manner of arbitration award the act ,time manner and publicat of award refused to sign must does not invalidate order specifications,setting a side of award ,cashing of cheque,the relationship between card ,issue and card hold traveller ,the low of trust basic feature a ,trust transfer control ,, right consequences of windings the effect of windings, liquidation meeting land proof ...- the low of administration of estate ,the executor ,appoint , furnished of security removal and dischat ,master , preliminary work ,death notice , letter accept ,band security ,making over in space ,completed sell , redistribution agreement payment to creditor on brief 30. Explain: practice school management -management characteristics of management styles the main components of . - planning: explain planing cycle different level of planned the need for planning policy general guidelines for effective plan - explaun : step decision making ,routine and innovative. -explain : time management the importt plannit way in which time is wasted making effective . -explan time table drawing time variouse , drawing up time various types of time table .. - the annual programme , purpose of the annual progrt consii drawing, - plannt preparation and record and keeping. - culture activity in the debat society youth activities religious movements , competition. -explanation sport actuy ,the aim of school ,sport police, - basic requirements for successful organisation and control , organisation of sport various.- the education value wells organised . - Education excurssion - officii applit for sport. - officit applit plannit and organisations, number of excussioner ,prior asssssmt ,follow up teach. - follot up after .- teacher and human relations ship ,teacher and authority ,teacher and the princit, teacher and principles,teacher and colleagues,teacher Nd pupils teacher parents .. - class organisation and routine . Definition of class room management.the relation between teaching class manager , - the important of classroom management. -element if classroom management. Organising the classrt to create atmosphere for learning developing an effect classroit routine. - furnit arrangements changii classing storage and stirat facities.. - laboratory organisation pratical work . Grouping and teaching. - the structure Education department,head office advisory council for Education and training, regional control , circuit area office board of control ,board of many ,school committee hostel board ,parent teacher . - type of schot secondary school ,special school the . - explain correspondence and filing system: -the prescribed filing system ,subfiles , Directive regard mail ,register The school journal ,the visitor Matter arising from incoming corresponding. -explain : in service training: in service training for staff development aims the in servit training. -the task the principal: substance a travelling allowance Decentralized in service training role of head office in service . - delagating : What Delagaty means ,who delegates , in the school , difference bet ,the of delagatiib . - - co ordination : co ordinating teacher work ,subject meeting , coordination pupils , - performance: perfot appraisal performance appru , performance effective common value ,reviewing and analyse career development.- staring equipment,storeroom ,stick keeping teacher in charge ,papper order book kept number item , - safe check labo rules maint conductivity head office directorate ...- responsible post school ,power durie . - didactt oriet instruction and learning , Didactic principt condition ,the currit ,aim of the currit ,the selection and oral,(arraignment of learning .. - dudacting method and each ,lesson presentation evaluation .. - defining didact science pedagt ,.- didact and other relating teach ,didacic . - the didactic activit ,the didactic situat,general peadagogic andragific . Didactic environment. -tsxhook as didactic nature and structure ,task of the ,teach learning ,tertiary education institutions non firmaj cybernetics ,system theory . -------________________________________ explain: activity guidence, -explain : self knowledge psychopedagogie , decision making stage , - choosing partion,examinat,tertair Education ,social conductor ,human relationships,the work. -need that can fulfied through work ,the career attitude towards. - testing: questions such follot may be set nocturak pedestrian shi preferably. -a grupe discussed: stlabutthem courtesy and road usage -the educational objet:to orientate the pupit in the relationship between coutsey and responsibilities. -the learning objectives:to identify the character of courteous road usage determine level . - to accept a losit attit award the requirements. - explain : solving problem : during the unlaxjinf of new mean of discussion teacher must si that follotbasic fact concerning courteous road usage trafficking. - pupils Alfred have knowledge: steering : it is difficulties to determine the main character the relation courtesy and is not clear jointly lesson problem is formulated .. - good maneee : unlocki new content pupils asked traffic low pupils matter how disret further points , - dunctt: characteristics of courtesy can applier motorcycle .. evaluation pupils completed self questions,@= alway, 2 = often ,seldom - 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 8 of 18 traffic ,control - questions: wath is functt if a lesson objective ,his is lease object ,why is formulated of a learning objectives important in term minimt an skill level of achit. - why is lesson problem import give 4 reason..-what us primary with demonstrate lesson .. - wath is importy. - during introductory phase of lesson them . - which important prerequisite applies to group ...-----________________________________ 31. Life training religious,Cristian culture, art buchellor : Explant: administration Guide master form - explain spread gospel pratical & Admnistrat Guide master form , - questt after asked about . - introduction letter church member... -suggested sheet adver,suggested 1st years scheduled (33 weeks , - application form admnistration, -student address planer, -recors of tests marks and exams ,paymet of fees register, -attandance register , assignment register. - order for code cost and note ,record of orders, -certificate warding sample in cover ,-bible school survey compus registraty. -please take book apart except the last two sheet important documents read, certificate sample , certificate merited , certt Christian service ,diplome in Christ lead ,certt in word minister,licenciate in Christian ministries .. ------------------.... -32.explanation: marketing reseat the research process and problem . - structural eqt models ,neural networks,social net,- analysis ,factor analyse ,cluster analysis. -cass part , winscon power,stormt equt,canopy of core ,canopy production, food ,transitional housing ,picty word megabyt of ...-equipment,fabut -research report ,fundamt criteria if form of report the oral grapt presentation. - students guidence to office autimat : . Office start four kinds of infot infirmat processt operational office ,procedure office system office, - example of an office system designing and office ,system the impact of office automation on job. -office automation hard , -

computer and office how computer work disk drive,work disk driver input output ,device networks other office automation hardware. -the electronics desktop,system sifft ,operating system task operating syst command . - operating envy. -recors keeping : record keet concept ,record keet task ,record keeping application type of record keeping . - software . - choosing a package. -spreadsheets: - spread sheet and database packau ,spread sheet package other spread sheet facitie and graphs spreadshtappli a.. Item loyal customer te - 32 explain: Educational the Mrs in time perspective. Explain peadagogic and perspective history of Education development .- orientation : Greek idea sophist concepts ,Socratic idea of knowledge the platonic concept ,Aristotelian idea on the infrastructure of Education ,the stoic Telos formula , - Roman idea , earthing Christianity ,media volbidea ,humanistt ide ,pedagy becomes ,pioneer of peadagogic founder of pedagt become science of historical original and development . - methodology of the history of Education.: orientation field of reast nature of problem of research ,general methodict,post minded futt ,factuality individual b,open mind , Conte temporality , setting the regret methodology unrestrained complexity present and future ,nomothecity .. +Professional competence personal enrichment.comparaison ,method approach,basic science method of investigation,them design field ,invesy of contemporary them , hypothesis formulation, investigation ,collecting data making , established information Education ,interprefinger data writing, approach for research, problem historical problem historical anthropology approach Mets bletic , history. - explain : development of higher education in general.comment , concept higher education a time instituts history functioning ,modern ..-explain college university criticism , justice. - established ,some .. - English education system ,control Education used ,aim content , - note ,the act preamble to the act ..some stipulation--- Aspect of the provincial Education system : - Education control , religious instruction,teaching medium . - a natit Education dispensation coordination uniform in education matter , preliminary work for new Education dispensation .. - policy keep with policy principles : change in some important Education matter , preliminary Education primary and secondary , division to schools course , the grouping of school , provincial Education , -- - 35 .explanation :General psychology low - the identification of psychopedagogie two , -method of psychopedagogie test nationalism the experiemental testing the experiemental method the clinak methods, naturalism observations testing ,the functy of theory test verification , modification form of modern theory . - explanation of behaviour reductions, explanation pattern , psychopedagogie influenced school of psychopedagogie present phylosophie - motivation , : explain motivation questions acquired classifying working . - biological energy recurring need measure activai stimulus transaction - discrimination conditions: other classically conditions response , instrumental learning and operant conditioning..- - reward and principal of reinforcement three learnings situation narration rewards non continouse extinction, stimulus generation learner reward negotivr reinforcement and motivation. .-learning : selective discrimination learning ,trial and error multimensionaliry learning.. - motor skills learnings motor skills task distribution of , transfer of training feedbay knowledge. - verbal learning : general procedure verbal rate presentation vfactor some interpretation in verbal learning transfer of learning concept.. -cognition memory: Measurements of two factor of retention,short term memory information processing memory control language, development, hereditary some genetic principle . - maturation: patterns of development maturation and experience. - some devely topics : perceptual development language development of intelligence development of socisk . - sociality interiors change communication society .. -consumer psychology: attention getting methods effective of advy other aspects of , structure,purpose Personal patter animal socisk manipulation social acquisition. -motion : emotional in history analyse Lyman emotion physiology functionalite, facial expressions. - acquisition emotional: limitations emotional conditions, learning developing and maturation of emotional,theory.. -psychologicsl stress: selyes ,systt stress psychological stress psychomat. Perception : receptor function:vision audition ,faction and skin sense kinds, - psychophysic : detectsbily low sublimation perceptions scaling ,.- - organization's : reception audition faction the skin equilibrium. - origin perception: development perception at distance visual depth movement perception,sound locaty colour perception colour their... - subjective color after effect illusion. - attention : matter orientation Tracy passive stimulation select. -attentiin analyse : neurological attention negotivr didactt listening institute , attention brief stability. - conditioning : the learning concept classical conditioning ,temporal relation extincty recovered higer order classical response .. motivation .. _________&&_&& - learning and memory at school in Learning psychopedagogie persscpectuve perspectt components of the learning memory. - model , - the affective level of the learning memory process sensory memory. -the cognitive level of t learning memory process Short term memory -the normative level in the memory process long term memory Long term memory epis and semantic memory why do pupils forget learnings . -learning subject content school -ainm ,learning model for subject content planning phase , planning and preparing subject content effective learn ,planing execution phase.. - step in the learnerinf process with reference to learning pattern level of drilling reinforcement and competency , -product phase ,level of proficiency,level of structure complex , monitoring the prodtphase. - communication the teacher as the exponey Education in transition teacher communicayteach ,communicat process ,general process. Communicator style noise , - Educationak medit for effective teaching media practice subject : teach computer in education class PC Education use for teaching - learning purpose :.computer aide instruction single PC managed available and placement of teacher : - social aspect of classroom practice Communication classroom , emotional aspect authority flexibility. - acknowledge of father people motional encounter ,transfer of value personal aspect distance. -function of teacher task directed functionalite of the teacher the social emoy group . - life orit: explanation competency life skill ,type of skill life orientation study research in respect.- -role : of the the church in realisation the role society . - the role of occupy life in the realisation of wath do emplot exception terrait planing for life skill trait. - explain definition terrain delimitation,the desit of programmtfor skill training a primary or secondary,CVS develot ,life skill modej ,religit Education theory and lrat. Agraindinf of the subjey ...- - handling of pupils of : Motional assisted.. - benefits the individual , orthopaedic they ________________________________ Explanation: teacing the practice of nursing a text nursing didactic th. - nursing educst the phylosophie of nursing ,nursing educst . -the scope of practice of a registered nurse . - the scope of the role nurse. - the scope of pratice of enrollment nurse . - the independent and dependent of nurse ..the independent functy of nurse . Phylosophie of nurse ...- the historical of nursing education outline ,:introduy , nights syst, amercain system ,conbtini. - purpose : and object nursing education.: selected of Education object in nursing ,decide what student ,plan implementation plan , evaluation. - authoritie responsible for providing education . -regulatiin affecting nursi Education: Regulation country council ,RSA ,training registration and enrollment ,types course a Aila le registration, --_------------------ Safety health aid tools hand ,,,. Education safety health occupation,security. ,, ... Explain: what is pedagy importance of pedagogy in teaching and learning process , - what is pedagogy, - what is the pedagy in teaching, - difference between a pedagogical approach pedagogical technical. - type of peadagogic, - role of pedagogie, - pedagogie is method of teaching in theory pratical understanding student. - pedagogie in teaching in refer educator student lead ,LMS , construction. - teaching quality of teaching, encourage cooperation learn , eliminate mono learning. - pedagical technique ,a pedagogical technique. : defines a set of action performance by the teacher in the classe for teaching include flipped learn learning computational thing and stepped learning it is more granular Thant . - technological pedagical content knowledge understand of how teaching learning can participate framework an education. - technologiCal pedagogical content knowledge framework integrating knowledge record. ________________________ - Engineering pedagogie educating ,focus if view of engineering pedagy is the development teaching concept creation for the preparation of further Engineering leadership roles changing . - explain problem base learning TVET engineering electrical, ________________________ - explain ,educare qualifications has been designed for people love work with children be able growth development child phrase .. ______________________ -explanation psychotechnique ,: system of actor training preparatory Deve theatre practical test measurement large verbal numerique ,test permis, suspension, permit v. QI. = Quotient intellectual ,age mental /age chronological . recruitment test suit logic. Is used to determine the degree of extrave Ce emotional stability professionalism ,as employment,is concerned accord board dimensions psychopedagogie. -____________________________ Psychometric test : the main goal of an aptitude test is to ensure that a candidate passes the amount of skill and cognitive ability to perform the duties of job role the common skill set measure test numerical verbal and non verbal rea ... 39.Explain: pratical school , orientation industrial trade Pratical nated , - promote standardisation in trade and industry is one the objective of council ,CSIR -orientation industrial in electrotechnology.standard industrial draw and label gate by EIC system gate output,,explain neer . orientation industrial : in electrical trade theory ,domestic appliances: type machine washer , ,,- maintenance out replace element tasg ,replace ,stei pannej ,, - orientation industrial in plant operations theory ,chemestrt and chemical processing ,cellulose fibre material ,manonr,readrvcombustion fuel and thermal insuy,,transfer heat pump, mechanism , convection. - orientation industrial advantage close cooperation compagny ,industry ,, Functionalite supervisor control responsibility,the aspect to prevent is to teach workers not tact :teach work Teach worker. Discuss different between Education and training .. government instituts. - a supervisor realise account organisation position direction tools ,, - importance diRectiob stragie ,operationel ,, - supervisor selection worker job tools need , employees training performance - operator is need mechanical workshop machine operator for stocking material - industrial orientation in trade electrical Operator stock material orientation, By protection ,heart, illumination. Application , equation AC ,DC - ______________________________,_ -In dbe to isita project to teach workers In dbe teaching worker training direction practice workshop dbe ..compagny corporation City power Eskom : exam national DBE ... Explanation , orientation industrial vs manage supervisor,vs management system information vs manage system information in education key challenge n Career posting time table counseling: trademarks industrial compagny trade theory license and trade pratical license. Orientation industrial Teach sork disciplinaire work communication skill team study team operational discipline teach counselor assessment and facilitate team value Journal classwork average score Counselor statement ,by psychometric goal work counselor conduct misconduct coursework engineering Counselor engineering studies creation Portofolio assessment,and planing by ruling courtesy low common . In dhet ,,in DBE workshop technologie Counseling project by orientation checking low outcome workers project isita umalusi electrotech EIC commissioner in job experience -Minister creation secret arrested ministerial letter appeal step. Minister dhet and DST building infrastructure government system careers creation authoritie building creation, counselor conductor, complain compliance duty Orientation industrial guidelines project workplace disciplinaire, questions number of task number job project marktrad licensed , -appeal release result irregularity,non accreditation school instituts research trade training to minister ucpd , development isita creating DST ,supplier profile , regulation,minister irregularity creating diploma technologie system DBE and recreating system backlog ista Teach appeal low Education processing learn ,by abscent Clauseoffice ucpd record learner orientation ministers teaching students practice counseling orientation industrial and marking process presentation ucpd and DBE system was learn job in trainer training . - explain: isita project orientation industrial counseling experiemental - pratical experiemental irregularity assessment. back log ,,time table n4 ,,and time table n3 trade theory examination .. Irregularite suspension 12month ,n4 rwiten final n6 ,n5 final examination,final soon n4 examin irregularity final Examination assessment years academic final , -Level 5,6 framework qualifition letter no qualifications isita back log . Irregularite: 12 additional information pratical process learner completed: Management system information Level 1,2,3,4,5 vocational principle police theory ,applied resolved Orientation: principle . information management system: Pratical 12month ,18 month pratical subject pratical exam school . Topics test n 6 .. -in high Education subject assessment moderation project: In dbe subject it orientation vocational guidance: outmark DBE filing pratical Poe s Isita project student make computer Learning lecturer computer subject , orientation skill training computer system - information system , :computer - quest operating system ,display option control panel gives , - system tool data computer . Option , change display ,system defragmentation display.. - uninstall program system programs feature ,, physical formatting Calle relative , ram room cache memory ,folder created. - Process of converting or data into prevention b, software , fraudulent vpratice email personal information ,infects . - format pictures style drop ,use ,,spread is opened ,insert formulae .- appropriate spread sheet v. - appropriate functy determinat the price contract router .. - computerised systeme Create a news set of name select file compagny , - compagny parameter , business - word processing : create services invoice ,use Arial 12 pt , all .. - leave two line space , key ,, - unit and replace word megabity ,save file A,,fibre .. - irregularity,isita project back log record complain subject .. Assessment mathematics: -Orientation industrial and trade mathematics :teach workers ,trainer workers supervisor ,standard measure -Management supervisor, :mathematics Computer system management -geometrical, algebraic ,limited , dervide function Prove ,radius area high calculate approximate change in volume: V= π.r.r.h -use partial fraction to calculate b.. -determind particular solutions integration. - sketch the graphs of , the area bounded . determine the length of curve , equation, - calculate surface the curve , x ,y is rotated--- Engineering ,orientation industrial: engineering physics T# compression : Heat heeded to bring heater , Heat gained ,heat lost - electrostatics: Power = w/t the amount of energy . - heat gained ,atom , frequently ,the energy of each ,,thermionic ,optical ------------------------------ - electrotechnical : DC : excitat motor control obtat adjust, Alternates - power 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 9 of 18 developed,rotor output ,, Power input = rotor output rotor . Energy Industrial electronics ,transient ,calcul value resistance to allow oscillation , Transducers : standard current ,step .. - ultrasonic x -rays and radii activt: the energy can transmitted the energy genert high , - electronics safety device and electronics ,regulator system. -thyristor device and scr speed . -,programmable logic controller.. Pratical industrial in dhet high irregularity regulation material project ,, Outmark .. - Counseling: project In dbe project workshop counseling Management supervisor workshop engineering,isita record academic ucpd Create diploma: certificate Counseling industrial electronic electrotechnique mathematics ,in trade theory electrical ,material irregularity DBE disciplinaire 11month suspension marking progress .appeal minister Pratical, action take occured irregularity and complain address ,, qualifications subject: 18 month technology guidence vocational module. Explanation : career vocational science ,, explanation low Portofilio. The police introduction - section Career orientation profile, - selection process ; choose career answers. -question reward live leave , professional answers occupation. -student guidance counseling police opportunity,, career understand job sleep skill , duty correlation, - peace officer preami,duty assignment case involy policing ,salary career allowance, duties securite function compagny invesy,older private police no longer existed replacement ,in function ,police minim case senior college orientation profile,psychometric , polytropic test college Deb employ , task physical , deduction probation life insurance, professional, listening ,career ,profey a matter an amateur career ,Unifor report ,court syst , division Pre trial paralegal ,, - police officer entrance exam police measure the basic skill ,exN read word duty -what is community oriented in policing range , innovation organisation police improve skill project build communy , procedure,practice , activities residents ... Explanation: irregularity Error test used for diffece between two independent sample satisfactory distributor performance: -service ranking ×1 overall,raking difference ,d1=y1-y2.(Bid sum .d.d = s data analyse invest assot agreement irregularity and back log project trademarks nated in job ,step process respond , provisional tax payer and penalty , understand and late submission,file Portofilio education trade , ,maturity date Poe s social award student , coupon rate 14%, internet,tendered bid or submitting 12%, tendered assumed accepted ,(1009),I R 709 interested,pay + c / 100×d, 3609,c = rate interested order ,d= number of day , 60 day proceed,R,1000=(1000×17,49,, denomination acceptance capital emploie, capital reserve resent taxation total assets liabilities balance sheet,manufacture -pat total retrenct , provided tax liability,salary and interest tax sum tax norm tax tax free portion award , provisional tax ,income salary overtime , allowance award irregularity plug ,equal renumeration leave,less acceptance of quotation irregularity and back log . ________________________ 40..Management administration industrial , - products maintence tpm - H: rate of Quality products 98% ,ideal cycle time=0,8minute, f: actual processing time + j×g=0,8×400 t availability= s/c×100=400/600×100=87% -(m: operating speed rde= l / jx 100+0,5×0,8×100=6,25%,, - net operating rate = f/e ×100=(0,8×400)400×199+80%> I: performance efficiency ,+ m×n .100 ×+×100=(0,8×4000+80% -net operating rate = file + actual processing / operationek -process amount × actual cycle to operating+ 400 item× 0,8 % availability, Avat + operation time / loadshedding time day academic record and Pratical -net ... -time loading,400 Mon × 109+ workplace record accuracy,process running,planned down ,lost process ,time c- d ,, processing time ,, j×g operating time finished , external total, quantity processed ,total including losses memory , attander ,cycle , actually processing time - time × idee cycle actual appears= 400 item × 0,8 Min /400,, -ovarall ,, - job schedule job , production planning and control schedule date issued , relaxation total,credit 0-4 Min work earned ,1080 per× 0,4+43 Min work Min available work of 100 performance ,432 Min ,, 432/432 days of work = 90 out ,100 performance,Orla ,% is over all relaxation allowance mode rate .. ------------------------------------ B. Planned down time per day ,down time accounted for inhere proceed,-- a.manning meeting +29 minute loading time per day. A-B + 460 minute ,D ,stoppage loss per day ,break down,20 minute stop, 30 minute, adjustment -20 minute= 60 minute ,operating time per day -C-D= 400 minute ,G : output per day + 400 item file 42-Duty industrial trade college and industrial , - explanation ista project back log computer student make . -document wallet project office , appointment documents access post , -docuy wallet registration form appointment office , register documents employ, information recruitment documents Wallpaper wallet information,database stationery documents wallet ,arch office ,office size mass . - docuy wallet bank account ATM printer ,record book customer revie ,record registry I'd number system , documents wallet Portofilio job career , - database emploie system entry exhib , - emploie record trait job qualifications graduation training post advertised, - I'd register for customer entry databy job post sale reward , programme logic control custy logiy system I'd programmation language database .. - print I'd frame work student ,print I'd student information ,print I'd ,job duty post ,print task rosta ,price over time print labour .. -explanation: to -electronics digital analogic circuit: input a,b gate yes = a.B -storage : potentiometer coefficient resulted and reducing voltage integration by factor (6/12(initial ,x= 6/12 chart capacitor input , output and gate Inverter integral circuit dx/St,,6/4 ,13,, Sum,integer,summat,difference,RLC L.di/DT(R,,+2/c , integral.. -construction PC architecture design development: input unit yes mouse optical keyboard yes , card red,control unity memory RAM ,ROM yes output ,CRT didn't,CPU yes ,room ,yes I/o,year vertical ,8 bit 69 but ,64×#=655336, -memkry systt. -sequencw +3 yes ,0,25 yes ,a+b ,A,B rim , - row yes data ,yes gate output gate , transistor bibpolaire logic diagram ,static RAM ,select ,supplies logic , - booleen algorithm program read ,yes memory register , printer charge plate ,electrosty digital input ,character ,source ,Lazer mirror ,module ,ribbon tape supply. - data memory time yes, -128 sector memoire ,564 bit sector, input output devices microcomputer converter serial data , parallel decoding microspacev,ram 16×16 bineray yes -disc label plastic with write ed inde hold, - sectaire track ,2,255 but logic process read digital step motor, -ns ram yes ,ram yes ,ROM yes ,CPU semie conductor yes ,hard dic driver yes ,external yes flopy disc ,data 150 km to 12m,typical machine -3 bit /5bit/ secret,000A,/AAA@/ load AC ,oo#B/BBB - 00/ load output /001,001/ --- -pc specifications format : Intel core 7 , external 975@,3,3ghz ,Intel ,DX58SO motherboard ,6GB,g skill trident DDR-200 channel gaineard ,GTx580 sponsored by vertex ,wD 320 GB ,data iu hard drive ,Intel core ,i7870 ,Gigabyte ,P55-UD6 ,LG flatro ,a essential up grade components AMD,procedure,chip choice the starting dusk x 2550BEb, CPU ,,X4 , 646 upward faster closely processor direct conflict shoe improvement load processor specific benchmark 3 d tendered video encoder x 264 ,, - graphic upgrade ,new little graphic card up date gaming phenomenon power × 2550 choice graphic card filled card up grade ,sub R1,500 udger choice HD 5770bigger to jumping performance Dx ,10 gaming word in conflict , - platform up grade ,CPU u grade path for LGA ,775 socket mother PC 3Ghz,core ,3500 CPU ,4 GB of DDR,ram direct ,x9 tessellation performance heaven ,,2,5 / frame per second higher better ,base systeme with sapphire,HD 550/#7 - upgrade to HD 6959 -ditect ,x 9 gaming perfot.. -one the card edge graphic tracker #gb , sapphire 5850 Xtreme ,retailing R2000 ,price complain 6 pin power connector which PSU hard physical driver installed benchmark away result disappointed ,3 marks improvement word conflict did manage ,lost planet frame wallet being ,R2000 ligth completed reliable, - battery ,g ram ,slot ,#gb,systy memory sticks R150 ,ram benchmark -upgrading memory and processor GB ,test window ,CPU the HD , -weigth components for the perfect budgy building , perfect machine Mother board F#A75-M-R1.100, processor A8-3859-R1,300,, -ram ,corsair ,4 GB,,:1600mhz-R1000 -graphic ,xFx random:HD6670-R1000, -storage : 750 GB - R 619, opacity ,re R200,PSU corsair ,430w ,R470, chassis : cm elite 343/, total :R5,369 ------- Build test installation CPU Vital - compot case layer CPU guard lockdown,add cooler and fan fixing bracket underneath ,screw holes fitting connect mbod,fit the ram : open the catch snai lock. Motheboymemory Chanel ,# and 3 operator, Hook connect ,2+4 pin connector to mobo ,the 8 pin EPs cable whichever,. - test the company power that sucker uonturning , screwdriver,striking the balance corsair ,4 GB ,,1,600 MHz ,DDR3 ,liani ram share system,CPU gaming rate ,2,34 MHz ,and 1,600mhz case , - Pre the case bit ,atz mounting screws install the PSU ,bottoy cable module drop in mother remove CPU from mobo CPU - test it still works connect cable case fab ,tech analysis: 2560×1600 screen Gami surplus frame ,R14,09 flashi ,CPU rendering performance. - cindbonh ,R#1, Test ... 44.Explanation:Technologie compagny: Teasing compagny , requirements market technologie solutions customer product security surveillance network point , - mission : provide technology added value business provide quality products , - valeur accountability ,,. - LCD monitor screen size ,22,5" , 6 viewable image size : 546,86 mm display area : 476.H,,,268,2,v).. mm brightness , typical : 300 CD/mm, contrast ,ratio (typical) 600000:1(DCR) response time (typically) 5 ms , viewing angles 170/169,max ,, - resolution : 2920×1080@ ,60hz -HDCP compatible ,yes ,input signal : analogy ,RGB ,,and user control menu entry image ration source up ,consumption power ,on < 49 standard < ,wall mounted ,visa 100 mm , mechanical function tilt ,5-29 - special features : touch key USB , - type Gori - 335 case type ,ATx Min ,case motherboard : micro ATX , external up (up to 13"×9,7),(p4ready) - power supply: 400w Culp ,P/s with 22cm fan (20+4 pin socket ,775 ready,.,,5,25" drive bays : ,3,3,5" drive hidden , expansion slots: 7,I/O interfy USB × 3 mic ,1 spk ×2 cooling fans front ,80mm,×2,rear 80 mm×1, dimensions,(D×w×H): 410×182×425mm,M/t(cuft):1,73. - print mount USB audio high green LCD fan external ,= 4,5,25" and ,3×3,5" internal driver bays ,4× 3,5" HD ,system board ATX form facty ,13"×20,5 expansion slots standard ATX material steel , - dimensions: 52,25×20×45 cm - raid max modular cabling system durable , titanium mirror grade block wraps mesh cable to mention ,20 toal power connector for computer ,type ,ATX ,12 EPs ,22v maximum ,power ,fan ,135 m blue led ,PFC ,main connector , - rails PCI e connector ,2×6 pin ,,1×6+12 ,pin modular cabling support yes , energy efficiency ,up to 80 % ,over voltage , - network cable . 5 cabling : 500m,solid , 24 AWG,,0,5 mm ,pair ,grey ,305 m flex or solids ,to ,24 AWG,,05mm ,pair ,,cat 6 cable ,305 flex or solids ut,24 AWG ,0,57 mm ,4 pair Gray ,. - cable tester digital tester ,cat 5. - toolkit ,j-059 long nose pliers (159,mm) by micro cutting pliers ,by ,339 cable blade trividr hyp ,5022 wire stripper , by 567 telephonic plier ,8 p8 ,/-45 punch down tape,2,mm knife , 539 soldering iron ,39 w cable tester tweezers ,125 mm ,crysty, tester , tweezers 225 mm , crystal, screwdriver,+- module plug RJ ,- 45 / 7 PC , PC plastt box ,315× 255×55mm ,crimping ,tool ,Rachel type dual crimping ,punch down tools ,walls boxry cat singltpart,45 key Stine jack , surface ,car 5 double ,RJ 45 jack ,carb , - connector ,boot sleever ,RJ45 cat micron connector , standard cable make female ,15 pin VGA,extenst available ,in 2,0 m ,,3.0,,m,5 / male 25 pin,, -1000VA/2000VA,rack mount ups, - patch panel 24 port it cat ,5 a panel ,w,t back ,bar ,48 port cat ,5 panel ,, - battery voltage ,24 VDC recharge ,8 hours to ,90% charger input voltage ,2# vac ,, - or 220VA,, output,wave from pseudo,wave protection outshort city overload protection with current limiting protection ,659 VA line interactive ups ,auto restart recover , provide ovrlot protection size ligth,b microprost control ,proviy modem phone ,line surge protector optit , equipment input ,voltage , building DC start functionalite enable ups ,input commercial power range ,145 vac ,280vac,avr range ,265 vac , frequency ,59 ,z #0% ,, output commercial power, sine shared frequence AVR voltage , 229vac ,auto sensing transfered ,b gross weight ,6,2 ,size mm,D×w×H,,,, 260×96×135.. - data manufacture data security , securite technologie PC , undertaking ,self finger printing , maximum b,test winner , antivirus program,,engine ,anti spyware,antipising, systeme tuning, firewall,internet ,award technologie,double scan outbreak shield , integration block,file archive ,formal ,heurisy detectt of virus ,client security , manager server ,agent notbooj server memory ,, - - Serie projector ,3 projection sysy ,3,LCD ,panel,2 lense projects , system ,resoloi was resolution.. ______________________________& ,- adabase ,storage data, association, emploie..file edit mask array , more, systeme, session systeme, system data. Area program ,nucleus ,buffer pool / ,I/o General,file control block field data space command is added , database, Empl modification,leave ,,name ,title ,edit-- -Triggered: gitlab,/ GitHub /azure Issue test .. -Triggered electronic elektor technologie -Circuit microcontrol ,, -Gitlab ,fail running Issue kananga ,, Engineering tshingombe Project ,commited contributing ,code source ... tshingombe fiston Sep 16, 2024, 9:29 PM (5 days ago) to tshigombekb, me Explanation: asssessment task management system information Back log isita : orientation police career Pratical Platform software engineer,policy data right met career ,detective career electronics engineering,detective met Tableaux design analyse investigation research police forensic digital print report , intelligence felonies vector design source analyse report evidence - ID submission: 22255 Your :tableau blue print assessment results thank ,completing blue print assessment:: Find everything building action plan get started tableau kit collection resource whitin organisation ,creating data culture happen by flipping a switch professional: - agility deployment monitor maintence typically,it led effort understand board technical requirements. - capabilities agility ,low high . - recommendations to building your agility capabilities,recommattiin to building server , understand hardware, network, database , application is first step in planning server installation. Review tableaux deployment section , completed the enterprise architecture in the the tableaux bluepri planner . - leverage installation can tableaux server implementation to deploy authenty and details, configuration. - manage tableau licensed: license be manage accordt sofft license process allocating ,use changing tableaux analyi skill in trade , reclaiming available tableau licensed . - reviy tableaux license level for the company. - deployed client software desktop prep builders,if virtual desktop determine want to manage license. - monitor tableau server process status server process monitoring back group job runseever ,job include extra data slots admnise process fail so corrective action can be taken ,, - configuration critical information platform outage take immediate. 2 - configuy notification system alert and faillure process state drive space constraints instat. - define a process how admnistration will response alerge triggered issue ,, - reviews performance thresholds Claude understand systeme proactive admnistration view. -monitor license utilisation administration monitor usage answer using if you need , - review admnistration view for monitoring. - completed loadtrst capacity planning load testing understand data work load usage capacity planning , - performance database maintence free space review database maintence.. Installation add extension on tableaux. -- -tshingombe Tshitadi - Dev Engineering south africa traiblazet profile : communauty .sale force : Rank 115 badge | 22,125 point |7trails - earn ,6,875 more point reach maintence - career mode , certificate - network security planning, application ,security basic , network care ,security ,cyber security threat and three -------------- Work book : tshingombe , executive, summary Pipe : value , discovery , negotiation,prose , qualifition,, - topics learn objective take stock of your building energy use stationnnary assets data for key field ,few calculation . -refrigerant emissions factor : global warming (GwO) Coolin create record . Auto calculated , emissions in CO2 ,scope corresponding ,entered , -:sum explored key information energy record for a stationary asset emissions ,Miami stationnnary asset envirt,fuel const details NTO headquarters Miami , monthly electricity bill ,electricity 1000kwh ,NTO diesel 1000 litre NTO headquarters ,W1 refresh bilk ,10kg ,calculation of electricity related emissions,the unite state ,us .. C02o emisst rate for location based emissions factor = 396,78 g/kWh Location - based coal -miz percentage ,20% Location based gas mix, 47% Location based nuclear. , 11% .. - scope ,2 location - base emissions (tc02)= electricity consumption (in kW) - emissions factor (g/kW) ,/ 10^6(tC02, convection factor ,100*396 .78 / 100000000= 0,3968t ,c02 ______________________ - information is calculate ,base grid mix - location based electricity from coal (kWh) 29% of 100kwh= 200kwh. - location based gaz 47%,10000=470kwh - grid mix stationary cálcul,12% of 10000kwh = 11000 - Simi core reference fuel factor record warning potential GwO of CH4:28,GEO of N2l=265,,CH4 emissions factor ,co 2 emissions factor ,C02 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 10 of 18 emissions factor ,N2l.. - diesel : 15 kWh ,, 12,45 tones / MWh,, Consumption of diesel (1000litre is first converted to is kWh , calorific value ,15 kW/ K,, - total fuel consumption = 1500kwh (1000×15) = 12,45 × 15000/1000)=186,5 Calculate refrigerant emissions are calculate fuel type is refrigeration sulfure Hexa fluoride (sf6)- IPCC ,,AR ,2007 refrigerator emissions factor record specific global warming. - scope , emissions (tc2e)= GwO)=Gwp×fuel . Green house gas emissions result on stationery asset enert. - Salesforce helo create a stationed asset environmental source record. - Map, stationnnary asset environmental record type . - create an electricity emissions factor record - create an electricity efactor record ,other emissions factor set record .. - Grid mix information : comparison data Quality metrics ,, - eisten case case predictive intellence Consol , Zero claud calculate ,daily energy consumption ,F gaos --- Action user tableau cloud . Wath is action specify user taking this site user name ,wath action user taking , Line x coordination -2 to 150;,, Access interactive action ,,0,50,1000 - published download action ,, subscription b.. - item name ,action :. opportunity tshingombe pipe ,use data source . -home ,,access view -engineering tsht : ----publish workbook Executive ,summary ---- access view - pipeline analyse ,access view - login ,access view , published workbook published data source ,user data ------------------------------------ - metropolitan: met request intellectuel property ,IP license ,date 03 July ,2024,time ,this form has been sent to metropolice police via online home report serviceuser>library tree app data >code user profi\e 1{ 2} 3 name : build , code quality 4 name build ,code quality 4. 5 job 6 build 7 8 9 run - on Ubuntu - latest 11 12 step: 13 uses : action) checkout @v1 - name : set up .JD 1.8 - uses : action / setup - with app name : Wze ba) sample token: ${{ secret.APO _ center_ Group Tate File aoo build outmname upload artefac to app center with File aoo / build) outbut) aoj - start- contribution Module Zejdu / aoo center - gthub action Report abuse Aoo center distributee update note is not certifie by GitHub On Thu, 10 Oct 2024, 20:25 tshingombe fiston, wrote: - continuing and training,act No16 of 2006 amendment,NQF ,act No 67 of 2008 ,as amended , determination phase N1-N3 term ,sect 42(1)(a) training dhet ,N1-N3 juanert ,2024 , dr zimande trade test ,trade occupation revise.. --testability checklist at the schematic level. - testability checklist at the PCB layout level , - revising design. Win existing ICT creating a test point report manufacture.,PC designer PCB relay project status information,PLC. - PLC wiring ,main breaker switch busbar circuit breaker SMP digital input output analif input terminal. -reaning PLC wiring diagram, profit bus communication PLC , digital input card diagram ,PLC digital Re: for multiple positions Inbox TSHINGOMBEKB TSHITADI Fri, Sep 20, 2:47 PM (20 hours ago) to Thandiwe, me On Thu, 19 Sep 2024, 17:15 Thandiwe at Jobrapido, wrote: Unsubscribe You've been a little distant lately. Have a look at all the jobs you've let slide Engineering Electrical / Engineering - 15km Apply Now Engineering Electrical Apply Now Remember to keep your searches simple, updated and fully completed EDIT YOUR SEARCHES Help Center | Unsubscribe Jobrapido S.r.l. via Paleocapa, 7 - 20121 Milan - Italy- Tax code and VAT number: IT11876271005 You are receiving this email because you subscribed to the Job Alert service, accepting Jobrapido's Terms of Service and Privacy Policy . Re: FW: SABS- Online enquiry Inbox info@sabs.co.za Thu, Oct 12, 2023, 11:06 AM to me Good day, Tshingombe Thank you for your e-mail enquiry. According to the information below, your enquiry has been identify as complaint. Pleaser elaborate more on your subject. Regards, MamtshaliMefane Customer Services T: 0861 27 7227 | T: +27 12 428 7911 | F: +27 12 344 1568 | www.sabs.co.za >-----Original Message----- > From: INFO@sabs.co.za > Sent: Monday, October 9, 2023 6:31 PM > To: > Subject: SABS - Online enquiry > > Online Enquiry > Subject: Complaint > Name: Tshingombe > Surname: tshingombe > Phone: 0725298946 > EMail: tshingombefiston@gmail.com > Company: Tshingombe assessment engineering electrical > Address: Percy Street 20, Rockview 103 yehovill jhb SABS Client: No Products / Certification: Trade engineering electrical research city power , Education Engineering electrical > Industry: Other > Comments: Education Engineering electrical subjects nated > DISCLAIMER:This electronic communication is sent from the SABS Group of Companies and complies with the communication requirements of the Companies ACT. For further information please visit http://www.sabs.co.za/Terms/index.asp Your SABS EMC Department order confirmation Inbox SABS EMC Department Sales Sat, Sep 14, 5:48 PM (7 days ago) to me tshingombe fiston, Thank you for your order from SABS EMC Department. You can check the status of your order by logging into your account. If you have questions about your order, you can email us at emc@sabs.co.za or call us at 012 428 6700. Your Order #4000000618 Placed on Sep 14, 2024, 5:47:42 PM Billing Info tshingombe fiston rockview 103 / yeohvill ,jhb percy street 20 jhb, Gauteng, 1030 South Africa T: 0725298946 Payment Method Bank Transfer / Wire Transfer Direct payments to be paid into: SABS Commercial SOC Ltd, ABSA Brooklyn 40-5322-5013 Branch No: 632-005 Items Qty Price ALABFULLTERM SKU: ALABFULLTERM A-Lab Application ID 14 1 R120,000.00 Subtotal R120,000.00 Grand Total (Excl.Tax) R120,000.00 VAT (@15%) R0.00 Grand Total (Incl.Tax) R120,000.00 Thank you, SABS EMC Department! DISCLAIMER:This electronic communication is sent from the SABS Group of Companies and complies with the communication requirements of the Companies ACT. For further information please visit http://www.sabs.co.za/Terms/index.asp Disclaimer The information contained in this communication from the sender is confidential. It is intended solely for use by the recipient and others authorized to receive it. If you are not the recipient, you are hereby notified that any disclosure, copying, distribution or taking action in relation of the contents of this information is strictly prohibited and may be unlawful. This email has been scanned for viruses and malware, and may have been automatically archived by Mimecast Ltd, an in IEC Special offer with IEC 62368-1:2023 Academy Masterclass. QUO-004536 Inbox IEC Sales Department Fri, Sep 20, 1:07 PM (21 hours ago) to me Dear Sir, Thank you for your quotation request. Following your registration to the IEC 62368-1:2023 Academy Masterclass, you will find attached our special offer for the purchase of IEC 62368-1:2023 RLV. Quote Nr. QUO-004536 totalling Swiss Francs CHF 578.40. This quote remains valid for three months only, after which it will automatically be deleted. Please note that prices in EUR and USD are given for information purposes only and as per today's exchange rate. You may proceed to the payment online through the following payment link. We remain available shall you have any questions. Best regards, IEC Sales Department T +41 22 919 0211 IEC – International Electrotechnical Commission 3 rue de Varembé, PO Box 131 CH-1211 Geneva 20, Switzerland www.iec.ch Re: Ticket #ZPQDJ: PC format saling magazine Inbox TSHINGOMBEKB TSHITADI Fri, Sep 20, 2:47 PM (20 hours ago) to 6236161+ZPQDJ, me On Mon, 26 Sep 2022, 14:23 , wrote: Your ticket is now solved! PC format saling magazine Tom Mon, 09/26/22 2:23 pm Hi Fiston, Greetings from Magzter! Please share your query in detail so we could assist you better. Thank you. fiston tshingombe Sun, 09/25/22 5:58 pm Message: PC format electronics Re: Magnum enquiry Inbox TSHINGOMBEKB TSHITADI Fri, Sep 20, 2:47 PM (20 hours ago) to Gail, me On Mon, 26 Sep 2022, 08:17 Gail Osborne, wrote: Hi Tshingombe, Thank you for communicating with Magnum Magazine. Please clarify what cost you are looking for so that I can provide you with a quote: 1. A subscription to Magnum Magazine - let me know your street address so I can find out if you can receive hand delivery 2. A back issue of Magnum Magazine - let me know which edition/s you need so I can check on stock 3. A copy of the book "The Lighter Side of Hunting & Shooting" - let me know the name of your nearest Postnet branch 4. A copy of the "Magnum Tactical Guide" - let me know the name of your nearest Postnet branch Thank you. Kind regards, Gail Osborne Senior Sub-Editor Magnum Magazine PO Box 35204, Northway, 4065, KwaZulu-Natal, South Africa Cell 084-432-1306 Fax 086-520-3711 www.manmagnum.com Your opinion matters: Please complete the evaluation for the course: Maximize Profitability and Operations Efficiency 2/3 Inbox noreply-MyLearningLink@learning.se.com Fri, Sep 20, 3:15 PM (19 hours ago) to me NB: If you have already completed the evaluation or rated this course, please disregard this email Dear Tshingombe, Congratulations on completing the training Maximize Profitability and Operations Efficiency 2/3! Continue your development journey by putting into action what you learnt: did you know that you will have forgotten 80% of what you learned if you do not apply it in the following day? • Think about how you can practice what you just learned • Take actions to ensure you succeed: reminders in your calendar, meeting with peers, manager... • Share your learning on Yammer or in the relevant community using #whatdidyoulearntoday Please also tell us what you thought of the training: your opinion matters! • If the Training has an evaluation, click on the below link to complete the survey: • Review the training using the star ratings For any questions about this training, please open a ticket in support@Schneider Keep on being curious and open to new challenges! #LearnEveryDay Thank you! Your Learning Team #whatdidyoulearntoday Any Questions? Visit My LearningLink Help or contact your helpdesk CSRe: TopGear Mag | Subscription Form Inbox TSHINGOMBEKB TSHITADI Fri, Sep 20, 2:47 PM (20 hours ago) to mlungisi, me On Wed, 28 Sep 2022, 12:27 Mlungisi Ngwenya | TopGear South Africa, wrote: Good day Thanks for your interest to subscribe to TopGear Magazine, would you please furnish us with your billing details that we may be able to begin the on-boarding process and send you an invoice. Best regards Mlungisi Ngwenya Re: Sale .buyer trade.. library bibliotech Amazon booking order ticket money market account refund statement conciliation Inbox TSHINGOMBEKB TSHITADI Thu, May 30, 2:26 PM to comments, me, TSHINGOMBEKB, tshingombetshitadi On Fri, 16 Sep 2022, 07:36 TSHINGOMBEKB TSHITADI, wrote: Hello dear saler tax invoice Ce claim..reclaim sta Application.mr tshingombe tshitadi TSHINGOMBEKB TSHITADI Sun, Aug 25, 1:04 PM On Fri, 16 Sep 2022, 07:36 TSHINGOMBEKB TSHITADI, wrote: Hello dear saler tax invoice Ce claim..reclaim staApplication.mr tshingombe ts TSHINGOMBEKB TSHITADI Fri, Sep 20, 2:47 PM (20 hours ago) to comments, me Your Internet Archive item has been reviewed Inbox The Internet Archive Thu, Jun 27, 12:22 PM to me Dear Archive Patron: A review was recently written for your item, https://archive.org/details/2-ltter-tshingombe-self-asseme-incident-logged-on-2024 at the Internet Archive. We thought you might appreciate knowing this and might want to read it by clicking on the link above. -The Internet Archive team. metropolis@abacusmedia.com Sun, Sep 25, 2022, 5:01 PM to me Welcome to Motor Trader Magazine Thank you for registering your details with Motor Trader magazine. You can also choose from: Daily Newsletter Jobs Newsletter You can change the emails you wish to receive anytime by clicking here I hope that Motor Trader Magazine will keep you informed and entertained and that you will take advantage of the free email services on offer. OD SYSTEM ID: 517377239 On Sun, 23 Oct 2022, 11:45 TSHINGOMBEKB TSHITADI, wrote: Money market extra savings Inbox TSHINGOMBEKB TSHITADI Mon, Oct 17, 8:23 PM (6 days ago) to help Hello claim extra savings money. 9710085084520751 Amount deposited money for gift receipt cash back magazine resend comments checkers MMA Support via freshdesk.com Tue, Oct 18, 11:15 AM (5 days ago) to me Hi TSHINGOMBEKB TSHITADI, Please note the amount showing on your slip is to show how much you have saved on goods. This amount cannot be used to buy anything. It is just to show that you have been saving on your groceries. Best, Thelma , TSHINGOMBEKB TSHITADI wrote: Disclaimer: https://www.shopriteholdings.co.za/email-disclaimer.html 1331500:961486 TSHINGOMBEKB TSHITADI Tue, Oct 18, 1:25 PM (5 days ago) Thank you for the clarification. TSHINGOMBEKB TSHITADI Tue, Oct 18, 1:33 PM (5 days ago) to MMA I m asking if can have letter of statement for that account number card confirm saling for that saving account to confirm that balance the saling that grocery or it will be give tendered statement cashback for saling or pay back returned savings account for the accounts . MMA Support via freshdesk.com Tue, Oct 18, 1:54 PM (5 days ago) to me Hi TSHINGOMBEKB TSHITADI, We cannot provide a statement for Xtra Savings card on our end. Please contact Xtra Sabvings Support on the below number. • Xtra Savings Support: 0800 33 33 85 Best, Thelma 1331500:961486 TSHINGOMBEKB TSHITADI Tue, Oct 18, 5:20 PM (5 days ago) to MMA Yes, I confirm. On Tue, 18 Oct at 1:34 PM , TSHINGOMBEKB TSHITADI wrote: I m asking if can have letter of statement for that account number card confirm saling for that saving account to confirm that balance the saling that grocery or it will be give tendered statement cashback for saling or pay back returned savings account for the accounts . On Tue, 18 Oct 2022, 13:25 TSHINGOMBEKB TSHITADI, wrote: Thank you for the clarification. On Tue, 18 Oct 2022, 11:15 MMA Support, wrote: Hi TSHINGOMBEKB TSHITADI, Please note the amount showing on your slip is to show how much you have saved on goods. This amount cannot be used to buy anything. It is just to show that you have been saving on your groceries. Best, Thelma On Mon, 17 Oct at 8:24 PM , TSHINGOMBEKB TSHITADI wrote: Hello claim extra savings money. 9710085084520751 Amount deposited money for gift receipt cash back magazine resend comments checkers Disclaimer: https://www.shopriteholdings.co.za/email-disclaimer.html Disclaimer: https://www.shopriteholdings.co.za/email-disclaimer.html Corporate Gift Cards | Website Enquiry Inbox TSHINGOMBEKB TSHITADI Oct 18, 2022, 1:58 PM (5 days ago) to giftcards Hi there, I'd like to enquire about your corporate gift cards. Below is my personal information: Name and surname: tshingombe Tshitadi Contact number:0725298946# Email address Amount of gift cards required: @100000rand to 1000rand Mart Marie Van Antwerpen Oct 18, 2022, 2:52 PM (5 days ago) to me Good day I hope you are doing well Please find attached the policies and procedures which should explain the bulk gift card process. This document also indicates the discount rates. If you are 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 12 of 18 interested in placing an order, please fill in your details below so we can create your profile for an accurate invoice: Name and surname of delivery contact :tshingombe Email address of delivery contact :tshingombekb@gmail.vom Telephone number of delivery contact :072529846 Cell number of delivery contact :0725298946 Company Name :tshingombe trade Delivery address (please include postal code) :103 Company address :rockview yeohvill jhb Postal Code : Company VAT number : Not Compulsory/ Denomination Quantity Type Total R x1200 X4 Gift Cards R x12000 12000 0 5 Gift Cards 12000 TOTAL 120000 Please ensure that the delivery contact is available to answer their phone and receive the gift cards from the couriers. Please note that we cannot take any responsibility for a delay in delivery when the delivery address or delivery contact details are incorrect. Please do not hesitate to contact me if you have any questions. Thank you Kind regards, Mart-Marié van Antwerpen Money Market Gift Cards 021 980 4727 / 021 980 4665 Request #87322: How would you rate the support you received? Inbox Support Unsubscribe Tue, Sep 17, 9:01 AM (4 days ago) to me Hello tshingombe fiston, We'd love to hear what you think of our customer service. Please take a moment to answer one simple question by clicking either link below: How would you rate the support you received? Good, I'm satisfied Bad, I'm unsatisfied Here's a reminder of what this request was about: Elektor Support Team (Elektor) 16 Sept 2024, 08:44 CEST EN0202272ID Dear Sir, Thank you for your e-mail. What's your question about the newsletter please? Hopefully we have informed you sufficiently, but if you need anything else, please do not hesitate to contact us again. Our customer service team would be glad to assist you. Kind regards, Marleen Brouwer Customer Support Elektor International Media www.elektor.com www.elektor.nl www.elektor.de www.elektor.fr Elektor is the media brand of EIM | learn, design & share electronics tshingombe fiston 14 Sept 2024, 16:47 CEST Become a Member My • • Topics • Magazine • Articles • News • Video • Projects • Newsletter • Submit • Store MyLAB EN0202272ID No bio • • • • • • • • 0 | Follow user View as visitor: My Groups Coming soon My Stats 0 Published projects Views 0 Followers 0 Star(s) on average 0 Comments 0 Comments My Projects • Letter experimental job experience: theoretical practical by EN0202272ID . requirement: .letter experimental work based log activities theoreti... 0 0 Draft • Education technology engineering electrical and trade by EN0202272ID Trade , pratical and theory ,Technologie technical electrotechnic elec... 0 0 Following Not following any project Subscribe to the e-zine Elektor is a great international source of essential electronic engineering information and innovative solutions for engineers, pro makers, startups, and the companies seeking to engage them. We helped launch the first electronics maker movement in the 1960s. Since then, our global electronics design community has expanded to include hundreds of thousands of active members and more than 1,000 contributing experts. We are proud to be growing every day as we inspire new members to design, share, and earn. Become a member • CUSTOMER SERVICE • Privacy Policy • Terms of business • Copyright • Contact us • Advertising info • ELEKTOR WORLD • Elektor MAGAZINE • Elektor LABS • Elektor STORE • Submit Your Content • Social Media • • Safe Payments • • BECOME FREE MEMBER AND RECEIVE OUR EZINE • THE ELEKTOR UNIVERSE ______________________________ tshingombe fiston 14 Sept 2024, 16:36 CEST engineering hello my question about published Hi there, a warm welcome from our Elektor community! For your records, below is a copy of the information you submitted to us. • Email: tshingombefiston@gmail.com • First Name: fiston • Last Name: tshingombe • Birthday: • Country: South Africa • Phone: • Address: Johannesburg, South Africa • Gender: • Company: Engineering tshingombe • Elektor Store: • Elektor Editorial Newsletter: • Elektor Industry Updates: • Vertical: • Education: • Field of Studies: • Field of industry: • Elektor Editorial Newsletter: Subscribe • Elektor Store: Subscribe • Elektor Industry Updates: Subscribe • Newsletter Subscriptions: Elektor Editorial Newsletter, Elektor Store, Elektor Industry Updates If at any time you wish to stop receiving our emails, you can: unsubscribe here You have questions? Contact us at: service@elektor.com T tshingombe fiston Member since 9/17/2024 ______________________________ Achievements To start earning badges, sign up to be a Product Expert in our Product Expert Program open_in_new . Activity Oct NovDecJanFebMarAprMayJunJulAugSep21 Community guides Community videos Questions Total replies Recommended User activity chart Post history Reply to Engineering electrical database Google Account•9/17/2024 Education technology engineering electrical and computer science data word excell windows school year vertical rising ground floor current location Engineering electrical database Google Account•9/17/2024 Engineering electrical database management system information, 1 reply Application Update Inbox Met Recruitment Team 9:35 AM (1 hour ago) to me Vacancy: 17878 - Specialist Operations Recovery Driver - Perivale Car Pound Dear tshingombe, Thank you for your application for a new position within the Met. To be eligible to apply for this new position, we have a set of criteria that applicants need to meet. Based on the information you have shared so far; we regret to inform you that you are not eligible to progress with your application. Your individual answers suggest that you do not meet the application criteria. You can read more about our eligibility criteria on our Careers Website or by reviewing information available on MyHR. We understand that this will be disappointing news for you but would like to thank you for your interest in this position and wish you all the best for the future. Shared Services Connected Ltd – Delivering services in partnership with the Metropolitan Police Service Phone: 01633 632500 Email: Enquiries.PoliceJobs@police.sscl.com Met Recruitment Team 9:40 AM (1 hour ago) Vacancy: 17952 - Student Placement - Portfolio Office Assistant - Change -2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 9:45 AM (1 hour ago) Vacancy: 17902 - LMS Administrator Met Recruitment Team 9:50 AM (1 hour ago) Vacancy: 17924 - HR Performance and Reporting Lead Met Recruitment Team 9:55 AM (1 hour ago) Vacancy: 17939 - Student Placement - Analysis & Research Assistant - Data & Analysis - 2025/2026- Counter Terrorism Policing HQ Met Recruitment Team 9:55 AM (1 hour ago) Vacancy: 17957 - Student Placement - Project Support Assistant - Change - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:00 AM (1 hour ago) Vacancy: 17951 - Student Placement - Junior DevOps Engineer - Technology - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:00 AM (1 hour ago) Vacancy: 17956 - Student Placement - Junior Service Designer - Technology - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:10 AM (1 hour ago) Vacancy: 17942- Student Placement - Borders Assistant - Borders Operations Centre - 2025/2026 Counter Terrorism Policing HQ Met Recruitment Team 10:10 AM (1 hour ago) Vacancy: 17955 - Student Placement- Junior Project Manager - Technology - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:10 AM (1 hour ago) Vacancy: 17941 - Student Placement - Project Support Assistant -Strategy, Performance, and Planning - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:15 AM (1 hour ago) Vacancy: 17908 - Business and Policy Support Officer - Data & Analysis - Counter Terrorism Policing HQ Met Recruitment Team 10:15 AM (1 hour ago) Vacancy: 17947 - Student Placement - Assurance and Standards Team Assistant - Change - 2025/2026 -Counter Terrorism Policing HQ Met Recruitment Team 10:20 AM (1 hour ago) Vacancy: 17948 - Student Placement - Associate End User Computing Engineer - Technology - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:20 AM (1 hour ago) Vacancy: 17823 - SQL Server Database Administrator - Counter Terrorism Policing HQ Met Recruitment Team 10:25 AM (1 hour ago) Vacancy: 17937 - Student Placement - Project / Research Assistant - Data & Analysis - 2025/2026 -Counter Terrorism Policing HQ Met Recruitment Team 10:25 AM (1 hour ago) Vacancy: 18030- Senior MetLaw Officer Met Recruitment Team 10:35 AM (50 minutes ago) Vacancy: 17980 - Police prosecutor Met Recruitment Team 10:35 AM (50 minutes ago) Vacancy: 17752 - Student Placement - Media and Communication Administrator 2025/2026 Met Recruitment Team 10:35 AM (50 minutes ago) Vacancy: 16279 - Experienced Intelligence Analyst Met Recruitment Team 10:40 AM (45 minutes ago) Vacancy: 17949 - Student Placement - Business Change Assistant - Change - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:40 AM (45 minutes ago) Vacancy: 17680 - Student Placement - Forensic Business Assistant 2025/2026 Met Recruitment Team 10:45 AM (40 minutes ago) to me Vacancy: 17959 - Student Placement - Communications Assistant - 2025/2026 - Communications - Counter Terrorism Policing HQ Met Recruitment Team 10:55 AM (30 minutes ago) Vacancy: 17853 - Enquiry Officer Met Recruitment Team 10:55 AM (31 minutes ago) to me Vacancy: 17830 - Programme Management Office Administrator Met Recruitment Team 10:55 AM (30 minutes ago) to me Vacancy: 16747 - 202402 - MPS Return Scheme Retired Officers Candidate added to Talent Bank Inbox Met Recruitment Team 9:35 AM (1 hour ago) to me Dear tshingombe, Thank you for registering to speak with the Outreach team. A member of the team will contact you shortly by your preferred method. If you no longer wish to speak to a member of the team, please click here to withdraw from our contact list. Many thanks, The Outreach Team Phone: 01633 632500 Email: TalkToUs@met.police.uk Outreach Live chat link: https://uk.meetandengage.com/al2rpqdab Your recent submission Inbox no-reply@service.police.uk 9:15 AM (2 hours ago) to me Thank you for completing the form, your reference is: MIP-482-24-0100-000. --- We understand how distressing being affected by crime or anti-social behaviour can be and we are committed to bringing offenders to justice and ensuring that victims of crime receive the support they need from us and from others. We have lots of crime prevention advice which you may also find useful. Consider our environment - please do not print this email unless absolutely necessary. NOTICE - This email and any attachments may be confidential, subject to copyright and/or legal privilege and are intended solely for the use of the intended recipient. If you have received this email in error, please notify the sender and delete it from your system. To avoid incurring legal liabilities, you must not distribute or copy the information in this email without the permission of the sender. MPS communication systems are monitored to the extent permitted by law. Consequently, any email and/or attachments may be read by monitoring staff. Only specified personnel are authorised to conclude any binding agreement on behalf of the MPS by email. The MPS accepts no responsibility for unauthorised agreements reached with other employees or agents. The security of this email and any attachments cannot be guaranteed. Email messages are routinely scanned but malicious software infection and corruption of content can still occur during transmission over the Internet. Any views or opinions expressed in this communication are solely those of the author and do not necessarily represent those of the Metropolitan Police Service (MPS). Find us at: Facebook: Facebook.com/metpoliceuk Twitter: @metpoliceuk no-reply@service.police.uk 9:22 AM (2 hours ago) to me Thank you for completing the form, your reference is: CNP-53345-24-0100-000. Tell us what you think of our online service Feedback on your experience of using our online services genuinely helps us to make sure they work as well as possible. If you have a couple of minutes, please complete a quick feedback survey. no-reply@service.police.uk 9:28 AM (1 hour ago) to me Thank you for completing the form, your reference is: FOI-22728-24-0100-000. This email confirms we've got your request. We'll reply within 20 working days if we can. If that's not possible we'll let you know. If you've told us we can respond by email then we'll do that unless the type of information you've asked for means we need to give it to you in a different way. If you've told us you'd prefer us to respond in a different way then we'll do our best, but if it isn't possible we'll contact you by email to explain. Application Update Inbox Met Recruitment Team Sat, Sep 21, 5:40 PM (17 hours ago) to me Vacancy: 17879 - Electronics Development Engineer Dear tshingombe, Thank you for your application for a new position within the Met. To be eligible to apply for this new position, we have a set of criteria that applicants need to meet. Based on the information you have shared so far; we regret to inform you that you are not eligible to progress with your application. Your individual answers suggest that you do not meet the application criteria. You can read more about our eligibility criteria on our Careers Website or by reviewing information available on MyHR. We understand that this will be disappointing news for you but would like to thank you for your interest in this position and wish you all the best for the future. Shared Services Connected Ltd – Delivering services in partnership with the Metropolitan Police Service Phone: 01633 632500 Email: Enquiries.PoliceJobs@police.sscl.com Met Recruitment Team Sat, Sep 21, 5:45 PM (17 hours ago) to me Vacancy: 17895 - Head of Visits and Events Met Recruitment Team Sat, Sep 21, 5:50 PM (17 hours ago) Vacancy: 17896 - Senior Media Officer Met Recruitment Team Sat, Sep 21, 5:55 PM (17 hours ago) Vacancy: 17897 - Media Officer Met Recruitment Team Sat, Sep 21, 6:00 PM (17 hours ago) Vacancy: 17912 - Communication Planning Manager Met Recruitment Team Sat, Sep 21, 6:05 PM (17 hours ago) Vacancy: 17918 - Senior Content, Channels and Engagement Officer Met Recruitment Team Sat, Sep 21, 6:05 PM (17 hours ago) Vacancy: 17927 - Head of Data Literacy and Culture Met Recruitment Team Sat, Sep 21, 6:05 PM (17 hours ago) Vacancy: 17874 - Quality Assurance Lead

Met Recruitment Team Sat, Sep 21, 6:15 PM (17 hours ago) Vacancy: 17686 - Service Design and Transition Manager - Band C - Technology - Counter Terrorism Policing HQ Met Recruitment Team Sat, Sep 21, 6:15 PM (17 hours ago) Vacancy: 17844 - Senior Project Manager - Change - Counter Terrorism Policing HQ Met Recruitment Team Sat, Sep 21, 6:15 PM (17 hours ago) Vacancy: 16896 - Lead Data Analyst in the Strategic Insight Unit Met Recruitment Team Sat, Sep 21, 6:15 PM (17 hours ago) Vacancy: 17866 - Business Change Manager - Change - Counter Terrorism Policing HQ Met Recruitment Team Sat, Sep 21, 6:20 PM (17 hours ago) Vacancy: 18011 - PALMLES Typist Met Recruitment Team Sat, Sep 21, 6:30 PM (16 hours ago) Vacancy: 17862 - Junior Data Engineer Met Recruitment Team Sat, Sep 21, 6:30 PM (16 hours ago) Vacancy: 17969 - Business Assurance Junior Manager Met Recruitment Team Sat, Sep 21, 6:30 PM (16 hours ago) Vacancy: 17874 - CTSFO Tactical Advisor Met Recruitment Team Sat, Sep 21, 6:30 PM (16 hours ago) Vacancy: 17834 - Operations Manager Met Recruitment Team Sat, Sep 21, 6:35 PM (16 hours ago) Vacancy: 17877 - Infrastructure Engineer Met Recruitment Team Sat, Sep 21, 6:40 PM (16 hours ago) to me Vacancy: 18001 - Lead Dev Ops Engineer (Cloud Platform) - Technology CSC - Police Staff - Counter Terrorism Policing HQ Thank you for your Application! Inbox Microsoft Recruiting 6:44 AM (4 hours ago) to me Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Job number:1755381) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you've selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Online Privacy Statement. Microsoft Corporation One Microsoft Way Redmond, WA 98052 Inbox Microsoft Recruiting 6:57 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Technology Specialist - Modern Work (Job number:1771873) position at Microsoft! We're glad you're in Microsoft Recruiting 7:02 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Software Engineering Manager (Job number:1766765) position at Microsoft! We're glad you're Microsoft Recruiting 7:06 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Applied Scientist (Job number:1762056) position at Microsoft! We're glad you're interested in Microsoft Recruiting 7:13 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Software Development Engineer (Platform Firmware & Drivers) (Job number:1732810) position at Microsoft! We're glad you're Microsoft Recruiting 7:16 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Supply Chain (Job number:1771684) position at Microsoft! We're glad you're Inbox Microsoft Recruiting 7:18 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Director, Cybersecurity Business Strategy Lead (Job number:1770318) position at Microsoft! We Microsoft Recruiting 7:21 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Product Manager (Job number:1736502) position at Microsoft! We're glad you're interested i Microsoft Recruiting 7:26 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Data Center Technician (Job number:1769625) position at Microsoft! We're glad you're interested in a Microsoft Recruiting 7:28 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer-Full Stack- Xbox (Job number:1771329) position at Microsoft! We're glad you're in! Microsoft Recruiting 7:30 AM (3 hours ago) to me Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Job number:1770175) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you've selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Online Privacy Statement. Microsoft Corporation One Microsoft Way Redmond, WA 98052 Inbox Microsoft Recruiting 7:32 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Job number:1770175) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you've selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Online Privacy Statement. Microsoft Corporation One Microsoft Way Redmond, WA 98052 Inbox Microsoft Recruiting 7:36 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Applied Scientist (Job number:1762056) position at Microsoft! We're glad you're interested in Microsoft Recruiting 7:13 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Software Development Engineer (Platform Firmware & Drivers) (Job number:1732810) position at Microsoft! We're glad you're Microsoft Recruiting 7:16 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Supply Chain (Job number:1771684) position at Microsoft! We're glad you're Inbox Microsoft Recruiting 7:18 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Director, Cybersecurity Business Strategy Lead (Job number:1770318) position at Microsoft! We Microsoft Recruiting 7:21 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Product Manager (Job number:1736502) position at Microsoft! We're glad you're interested i Microsoft Recruiting 7:26 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Data Center Technician (Job number:1769625) position at Microsoft! We're glad you're interested in a Microsoft Recruiting 7:28 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer-Full Stack- Xbox (Job number:1771329) position at Microsoft! We're glad you're in! Microsoft Recruiting 7:30 AM (3 hours ago) to me Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Job number:1770175) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you've selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Online Privacy Statement. Microsoft Corporation One Microsoft Way Redmond, WA 98052 Inbox Microsoft Recruiting 7:32 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Technology Specialist - Modern Work (Job number:1771873) position at Microsoft! We're glad you're in Microsoft Recruiting 7:02 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Software Engineering Manager (Job number:1766765) position at Microsoft! We're glad you're Microsoft Recruiting 7:06 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Applied Scientist (Job number:1762056) position at Microsoft! We're glad you're interested in Microsoft Recruiting 7:13 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Software Development Engineer (Platform Firmware & Drivers) (Job number:1732810) position at Microsoft! We're glad you're Microsoft Recruiting 7:16 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Supply Chain (Job number:1771684) position at Microsoft! We're glad you're Inbox Microsoft Recruiting 7:18 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Director, Cybersecurity Business Strategy Lead (Job number:1770318) position at Microsoft! We Microsoft Recruiting 7:21 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Product Manager (Job number:1736502) position at Microsoft! We're glad you're interested i Microsoft Recruiting 7:26 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Data Center Technician (Job number:1769625) position at Microsoft! We're glad you're interested in a Microsoft Recruiting 7:28 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer-Full Stack- Xbox (Job number:1771329) position at Microsoft! We're glad you're in! Microsoft Recruiting 7:30 AM (3 hours ago) to me Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Job number:1770175) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you've selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Online Privacy Statement. Microsoft Corporation One Microsoft Way Redmond, WA 98052 Inbox Microsoft Recruiting 6:57 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Technology Specialist - Modern Work (Job number:1771873) position at Microsoft! We're glad you're in Microsoft Recruiting 7:02 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Software Engineering Manager (Job number:1766765) position at Microsoft! We're glad you're Microsoft Recruiting 7:06 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Applied Scientist (Job number:1762056) position at Microsoft! We're glad you're interested in Microsoft Recruiting 7:13 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Software Development Engineer (Platform Firmware & Drivers) (Job number:1732810) position at Microsoft! We're glad you're Microsoft Recruiting 7:16 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Supply Chain (Job number:1771684) position at Microsoft! We're glad you're Inbox Microsoft Recruiting 7:18 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Director, Cybersecurity Business Strategy Lead (Job number:1770318) position at Microsoft! We Microsoft Recruiting 7:21 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Product Manager (Job number:1736502) position at Microsoft! We're glad you're interested i Microsoft Recruiting 7:26 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Data Center Technician (Job number:1769625) position at Microsoft! We're glad you're interested in a Microsoft Recruiting 7:28 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer-Full Stack- Xbox (Job number:1771329) position at Microsoft! We're glad you're in! Microsoft Recruiting 7:30 AM (3 hours ago) to me Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Job number:1770175) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you've selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Online Privacy Statement. Microsoft Corporation One Microsoft Way Redmond, WA 98052 USA Microsoft Recruiting 6:57 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Technology Specialist - Modern Work (Job number:1771873) position at Microsoft! We're glad you're in Microsoft Recruiting 7:02 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Software Engineering Manager (Job number:1766765) position at Microsoft! We're glad you're Microsoft Recruiting 7:06 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Applied Scientist (Job number:1762056) position at Microsoft! We're glad you're interested in Microsoft Recruiting 7:13 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Software Development Engineer (Platform Firmware & Drivers) (Job number:1732810) position at Microsoft! We're glad you're Microsoft Recruiting 7:16 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Supply Chain (Job number:1771684) position at Microsoft! We're glad you're Inbox Microsoft Recruiting 7:18 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Director, Cybersecurity Business Strategy Lead (Job number:1770318) position at Microsoft! We Microsoft Recruiting 7:21 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Product Manager (Job number:1736502) position at Microsoft! We're glad you're interested i Microsoft Recruiting 7:26 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Data Center Technician (Job number:1769625) position at Microsoft! We're glad you're interested in a Microsoft Recruiting 7:28 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer-Full Stack- Xbox (Job number:1771329) position at Microsoft! We're glad you're in! Microsoft Recruiting 7:30 AM (3 hours ago) to me Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Job number:1770175) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you've selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Online Privacy Statement. Microsoft Corporation One Microsoft Way Redmond, WA 98052 Inbox Microsoft Recruiting 7:32 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Technology Specialist - Modern Work (Job number:1771873) position at Microsoft! We're glad you're in Microsoft Recruiting 7:02 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Software Engineering Manager (Job number:1766765) position at Microsoft! We're glad you're Microsoft Recruiting 7:06 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Applied Scientist (Job number:1762056) position at Microsoft! We're glad you're interested in Microsoft Recruiting 7:13 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Software Development Engineer (Platform Firmware & Drivers) (Job number:1732810) position at Microsoft! We're glad you're Microsoft Recruiting 7:16 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Supply Chain (Job number:1771684) position at Microsoft! We're glad you're Inbox Microsoft Recruiting 7:18 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Director, Cybersecurity Business Strategy Lead (Job number:1770318) position at Microsoft! We Microsoft Recruiting 7:21 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Product Manager (Job number:1736502) position at Microsoft! We're glad you're interested i Microsoft Recruiting 7:26 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Data Center Technician (Job number:1769625) position at Microsoft! We're glad you're interested in a Microsoft Recruiting 7:28 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer-Full Stack- Xbox (Job number:1771329) position at Microsoft! We're glad you're in! Microsoft Recruiting 7:30 AM (3 hours ago) to me Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Job number:1770175) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you've selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Online Privacy Statement. Microsoft Corporation One Microsoft Way Redmond, WA 98052 Inbox Microsoft Recruiting 6:57 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Technology Specialist - Modern Work (Job number:1771873) position at Microsoft! We're glad you're in Microsoft Recruiting 7:02 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Software Engineering Manager (Job number:1766765) position at Microsoft! We're glad you're Microsoft Recruiting 7:06 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Applied Scientist (Job number:1762056) position at Microsoft! We're glad you're interested in Microsoft Recruiting 7:13 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Software Development Engineer (Platform Firmware & Drivers) (Job number:1732810) position at Microsoft! We're glad you're Microsoft Recruiting 7:16 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Supply Chain (Job number:1771684) position at Microsoft! We're glad you're Inbox Microsoft Recruiting 7:18 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Director, Cybersecurity Business Strategy Lead (Job number:1770318) position at Microsoft! We Microsoft Recruiting 7:21 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Product Manager (Job number:1736502) position at Microsoft! We're glad you're interested i Microsoft Recruiting 7:26 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Data Center Technician (Job number:1769625) position at Microsoft! We're glad you're interested in a Microsoft Recruiting 7:28 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer-Full Stack- Xbox (Job number:1771329) position at Microsoft! We're glad you're in! Microsoft Recruiting 7:30 AM (3 hours ago) to me Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Job number:1770175) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you've selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Online Privacy Statement. Microsoft Corporation One Microsoft Way Redmond, WA 98052 USA

Request an intellectual property (IP) licence | Metropolitan Police https://www.met.police.uk/rqo/request/ipl/request-intellectual-property...

University Chicago School of Law Stephen Rushin is the Associate Dean of Faculty Research and the Judge Hubert Louis Will Professor of Law at Loyola University of Chicago School of Law. He has published a series of articles on police unions and the officer internal disciplinary procedures. His research interests include policing, criminal procedure, and criminal sentencing. His work has recently appeared in the Stanford Law Review, the University of Pennsylvania Law Review, the California Law Review, the Cornell Law Review, the Duke Law Journal, the Vanderbilt Law Review, the Texas Law Review, the Iowa Law Review, the Minnesota Law Review, the George Washington Law Review, the Fordham Law Review, the Boston College Law Review, and the Florida Law Review, among other journals. He published the premier article on police union contracts in the Duke Law Journal in 2017. Rushin graduated from Berkeley (J.D. and PhD) and the University of Texas (B.A.). HOST Josh Parker, Deputy Director of Legislative Policy, Policing Project at NYU Law Josh Parker is the Deputy Director of Legislative Policy at the Policing Project. He is a policing policy and legal expert who co-drafted the Removing Barriers to Accountability model statute and has counseled legislators and agency leaders across the country on how to reform their laws to better address police misconduct. Given his expertise, Josh is often sought for legislative testimony, media interviews, and public comment on a number of police misconduct topics. He graduated from the University of Chicago Law School (J.D.), where he served as an Articles Editor of the University of Chicago Law Review, and Duke University (B.A.).21-CIP-J / FFPSA & Kinship (Part 1),Date & Time Sep 24, 2024 09:00 PM Johannesburg Webinar ID 912 5168 3181,Tue Sep 24, 2024 9pm – 10pm (SAST) Where https://nyu.zoom.us /w/91251683181?tk=9vyym4gehi0cHxdYwYdOOiYbUw2lCZzZ_IKD0ceCABo.DQcAAAAVPwYvbRZjNTdyNEx1S1NaQzljV2s3NlU2SEdRAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA& uuid=WN_3jfCNZddR7iCjsRfhRXPag Who Gabby Bayness 30x30 Initiative: Advancing Women in Policing Chicago Neighborhood Policing Initiative Legislation Litigation Regulating Use of Technology in Policing ReImagining Public Safety SAJE Policing Assessment Our Mission: We Partner With Communities And Police To Promote Public Safety Through Transparency, Equity, and Democratic Engagement. Our work focuses on front-end, or democratic, accountability—meaning the public has a voice in setting transparent, ethical, and effective policing policies and practices before the police or government act. The goal is to achieve public safety in a manner that is equitable, non-discriminatory, and respectful of public values. Broadly speaking, our work is centered around three focus areas: Front-End Voice in Policing: We believe that in a democratic society, the public must have a voice in how it is policed. Regulation of Policing Technology: We believe that there must be transparency and public debate around the adoption of new policing technologies. Reimagining Public Safety: We believe it is time for a national conversation about what public safety means, and how it is best achieved. Explore our focus areas to learn more about our work.*,. Name of CLE Provider: New York University School of Law - Policing Project Please confirm the following statements by checking the boxes and typing your name in the signature field below * ✓ I acknowledge receipt of the course materials for Removing Barriers to Officer Accountability ✓ I certify that I have listened to and/or viewed Removing Barriers to Officers Accountability in its entirety for the sessions for which I've entered codes. Therefore, I request that I be awarded the applicable number of New York CLE credits for this course. Signature * tshingombe tshitadi Date of completion of CLE course (New York attorneys earn CLE credit as of the date they complete a CLE course): * MM 09 / DD 26 / YYYY 2024 Attorney email address to receive CLE certificate (if different from the address above): tshingombekb@gmail.com Section 2: Course Evaluation Course evaluations are optional, but must be offered to all attorneys who participated in today's course. Program Title 21-CIP-J / FFPSA & Kinship (Part 1),Date & Time Sep 24, 2024 09:00 PM Johannesburg Webinar ID 912 5168 3181,Tue Sep 24, 2024 9pm – 10pm (SAST) Where https://nyu.zoom.us /w/91251683181?tk=9vyym4gehi0cHxdYwYdOOiYbUw2lCZzZ_IKD0ceCABo.DQcAAAAVPwYvbRZjNTdyNEx1S1NaQzljV2s3NlU2SEdRAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA& uuid=WN_3jfCNZddR7iCjsRfhRXPag Who Gabby Bayness 30x30 Initiative: Advancing Women in Policing Chicago Neighborhood Policing Initiative Legislation Litigation Regulating Use of Technology in Policing ReImagining Public Safety SAJE Policing Assessment Our Mission: We Partner With Communities And Police To Promote Public Safety Through Transparency, Equity, and Democratic Engagement. Our work focuses on front-end, or democratic, accountability—meaning the public has a voice in setting transparent, ethical, and effective policing policies and practices before the police or government act. The goal is to achieve public safety in a manner that is equitable, non-discriminatory, and respectful of public values. Broadly speaking, our work is centered around three focus areas: Front-End Voice in Policing: We believe that in a democratic society, the public must have a voice in how it is policed. Regulation of Policing Technology: We believe that there must be transparency and public debate around the adoption of new policing technologies. Reimagining Public Safety: We believe it is time for a national conversation about what public safety means, and how it is best achieved. Explore our focus areas to learn more about our work.*, Date MM 09 / DD 25 / YYYY 2024 Speaker(s): 21-CIP-J / FFPSA & Kinship (Part 1),Date & Time Sep 24, 2024 09:00 PM Johannesburg Webinar ID 912 5168 3181,Tue Sep 24, 2024 9pm – 10pm (SAST) Where https://nyu.zoom.us /w/91251683181?tk=9vyym4gehi0cHxdYwYdOOiYbUw2lCZzZ_IKD0ceCABo.DQcAAAAVPwYvbRZjNTdyNEx1S1NaQzljV2s3NlU2SEdRAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA& uuid=WN_3jfCNZddR7iCjsRfhRXPag Who Gabby Bayness 30x30 Initiative: Advancing Women in Policing Chicago Neighborhood Policing Initiative Legislation Litigation Regulating Use of Technology in Policing ReImagining Public Safety SAJE Policing Assessment Our Mission: We Partner With Communities And Police To Promote Public Safety Through Transparency, Equity, and Democratic Engagement. Our work focuses on front-end, or democratic, accountability—meaning the public has a voice in setting transparent, ethical, and effective policing policies and practices before the police or government act. The goal is to achieve public safety in a manner that is equitable, non-discriminatory, and respectful of public values. Broadly speaking, our work is centered around three focus areas: Front-End Voice in Policing: We believe that in a democratic society, the public must have a voice in how it is policed. Regulation of Policing Technology: We believe that there must be transparency and public debate around the adoption of new policing technologies. Reimagining Public Safety: We believe it is time for a national conversation about what public safety means, and how it is best achieved. Explore our focus areas to learn more about our work.*, Please take a few moments to evaluate this course: Excellent Good Fair Poor N/A Program Content ✓ Instructor Quality ✓ Written Materials ✓ Facility ✓ Technology ✓ Relevence to my practice: engineering project assessment police low enforcement portfolio discipline quality management evidence low in order police design thing resolve order in gov system orientation Comments: god thing on disciplinary conduct code police Job Description Schneider Electric's EcoStruxure™ Automation Expert (EAE) is a software-centric industrial automation system that creates successive improvements throughout your operational lifecycle. The EcoStruxure team supports countries globally in deploying this solution. Your role: Reporting to the EcoStruxure EMEA Manager (Francisco) and as part of a team of 7 Project Managers, you will participate in the deployment of the EAE automation solution in Europe. You will support our clients (internal and external) during pre-sales and project execution phases. Your main missions: • Promote the technical benefits of the EAE solution in Europe with Schneider Electric entities in the relevant countries (joint visits, presentations, demonstrations) • Provide technical support to Schneider's local pre-sales teams • Assist in creating technical documents, technical guides, white papers, knowledge base articles, etc. • Support pilot project execution and execution of key projects for clients (direct and indirect) • Train internal teams in different countries using Schneider's local technical resources • Develop the autonomy of each country in deploying EAE Your profile: • Master's degree in Engineering or equivalent in automation • 3 years of minimum experience in design and automation Your skills: • Understanding of OT (Operational Technology) and IT (Information Technology) convergence to address client sustainability challenges • Understanding of DCS (Distributed Control Systems) concept and implementation • Mastery of secure, open, interoperable, and scalable control systems • Appreciated knowledge of the IEC61499 standard • Aptitude for assembling software components to meet customer requirements • Software integration experience • Commercial aptitude, good communication skills, relationship building, collaboration, and teaching • Curiosity, organizational skills, and autonomy • Fluent in English and French We know that skills manifest in many ways and can be based on your life experience. If you do not necessarily meet all the requirements listed, we still encourage you to apply. We offer you: Our offer includes an attractive remuneration and goes well beyond. If you join Schneider Electric, here's an idea of all that we can offer you to live the best possible experience: • A competitive salary, individual bonus, as well as profit-sharing and participation bonuses rewarding everyone's efforts • A range of social benefits that make life easier: from CSE to rich catalogs, health insurance that meets all needs, generous savings and retirement plans, an advantageous employee share ownership program • Professional development through training, mobility and internal promotion (local and international), skills sharing, etc. • An integration journey from your first day 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 17 of 18 to give you the keys to success at Schneider Electric within a culture that promotes diversity, professional fulfillment, and inclusion • Work-life balance through our telecommuting policy (up to 48% telecommutable time, equipment included), support for parenthood, inter-company childcare facilities, etc." About Our Company Why us? Schneider Electric is leading the digital transformation of energy management and automation. Our technologies enable the world to use energy in a safe, efficient and sustainable manner. We strive to promote a global economy that is both ecologically viable and highly productive ob Description Schneider Electric's purpose is to empower all to make the most of our energy and resources, bridging progress and sustainability - we call this Life Is On. Our mission is to be the digital partner for sustainability and energy efficiency: https://www.youtube.com/watch?v=VbldHPFltQQ Great people make Schneider Electric a great company - and we are currently recruiting for a Budapest-based, Italian speaking Energy Sourcing Analyst to support the sourcing activity in the Italian market. You will be an active member of our energy and sustainability services group, vital to the future success of the business, and you will play a key role in assisting the team facilitate the delivery of our services to clients across Europe. Please note, this is an Entry level role within the team and this will be a Maternity Cover, starting out as a 2-year-long fixed-term contract with the possibility to extend. Purpose of the job: Deliver effective and efficient energy procurement services (for electricity and natural gas) for our Clients. Maintain effective working relationships at an operational level with key Internal (Client Management, Data, Solutions, Risk Management) and External Stakeholders (Energy Suppliers). Drive operational excellence by participating in process and service improvements in response to market developments and business targets. What you will do: • Analyze energy supply contract prices and terms and negotiate with energy suppliers to ensure optimal contracts are secured • Manage client and supplier relationships through excellent formal and informal communication • Work closely with the Client Management and other internal teams to deliver an exceptional level of service to our clients • Develop and maintain a deep understanding of the Italian energy markets and legislation • Maintain regular contact with energy suppliers in order to ensure flawless service delivery to our client • Effectively create/communicate regional market opinions and knowledge to internal/external clients • Manage pre-tender activities through collecting data, invoices, contracts, etc. • Manage the tendering, analysis and subsequent contract award and placement processes relating to complex energy supply contracts • Negotiate and utilise quantitative and qualitative techniques to deliver optimal energy supply contract terms and prices for our clients through regular interaction with the energy suppliers on the related markets • Collaborate with Sourcing leadership to identify, evaluate, and incorporate efficiencies, new services, and innovative ideas/concepts • Participate in budget forecast creation process What we need from you: • Excellent knowledge of MS Excel is a must • University/College degree preferably in Finance/Economics/Maths/Science or Energy related studies or equivalent experience in energy procurement / client or supplier management / contract management / negotiations • Fluency in English AND Italian is a must • Experience of the energy industry gained either at a supplier or an energy consultancy is a big advantage • Experience in multinational environment is an advantage Skills, competencies that can make you the successful candidate: • Strong analytical and logical skills • Be an excellent influencer, negotiator and collaborator, forming effective relationships with demanding stakeholders • Great communication skills, capablility of engaging people of varying levels in seniority and experience • Strong time management and organisational skills • Results focused and self-directed mindset What we offer: • Life, Accident and Health insurance packages (Medicover White Spring) • Cafeteria allowance • Home Office and Utility allowances • Yearly bonus • Global Family Leave • Flexible and hybrid working model • WESOP (World Employee Share Ownership Plan) to become a shareholder in the company • Engagement groups within the company: get a sneak peek to our company life at https://download.schneider-electric.com/files?p_Doc_Ref=Engagement_groups_HU • Working at the company that ranked #1 in TIME Worlds' Most Sustainable Companies in 2024 • International, diverse environment and a company culture that encourages raising questions and ideas - to make an impact • Real future career building opportunities locally & globally • Working directly with international customers dustrial / Manufacturing senior Engineering - 00934K • Manage the process flow and qualification in collaboration with BU and GSC to prepare a successful industrial transfer • Lead the deployment on NPI and capacity increase projects at the facility ensuring consistency between BU & GSC • Work with cross-functional and remote teams to guarantee the deployment of industrial processes • Accountable for decision making and project execution in compliance with project goals, business, industrial y customer requirements • Accountable for projects requirements: resources, product cost fie, planning & schedule, capacity, SPS and other deliverables • Decision making based on priorities and risk assessment • Ensure the capacities adaptation according to the dedicated tools (CAMA, CORIM, Bridge ..), internal or external • Perform regular Queue Simulations, using the waiting queue design tool, in order to optimize Lead Times and assure capacity of the lines. • Define & maintain a referential operating time based on measurement tools adapted (MTM-UAS-timer-video analysis.) • Ensure the profitability of investments adapted to the needs of optimization and development process Guide the choice of designers by providing industrial and logistical requirements • Is the "Time determination & Ergonomics Specialist/Referent" within his perimeter. • Responsible for Productivity action plan in his perimeter (define, implement) • Implement adaptation on the processes and manufacturing workstation for existing products by improving the industrial performance, in manual process, automatic process & PLC (Programmable Logic Control) using SPS techniques and tools. • Involved in the specifications and quotation of new line architectures and industrial scenarios in order to meet Safety/Quality/Lead Times and productivity requirements. • Optimize Lead Times and assure capacity of the lines. • Write operator work instructions for training • Study the feasibility & profitability of investments adapted to the needs. • Qualifies means and processes, in plant but also at suppliers' location. Application Update Inbox Met Recruitment Team Sat, Oct 26, 7:40 PM (16 hours ago) to me Vacancy: 18130 - National Referral Mechanism Coordinator Dear tshingombe, Thank you for your application for a new position within the Met. To be eligible to apply for this new position, we have a set of criteria that applicants need to meet. Based on the information you have shared so far; we regret to inform you that you are not eligible to progress with your application. Your individual answers suggest that you do not meet the application criteria. You can read more about our eligibility criteria on our Careers Website or by reviewing information available on MyHR. We understand that this will be disappointing news for you but would like to thank you for your interest in this position and wish you all the best for the future. Shared Services Connected Ltd – Delivering services in partnership with the Metropolitan Police Service Phone: 01633 632500 Email: Enquiries.PoliceJobs@police.sscl.com Incomplete Application Inbox Met Recruitment Team Thu, Oct 24, 10:15 PM (3 days ago) to me Vacancy: 14783 - 202305- Police Community Support Officer (PCSO) tshingombe, We don't think you want to continue with your application, and are sorry to see you go. We've closed down your application for now, so that we don't keep bothering you if you've decided this isn't the opportunity for you. If we've got this wrong, and you want to carry on, please get in touch and we'll open your application form back up. Our contact details are below if you want to give us a call. Being a Police Constable isn't for everybody, so we understand that sometimes applicants change their mind. If you've decided this isn't the role for you, but you're still interested in joining the Met, please take a look at the other opportunities we've currently got available - you can view our careers website here. Have a great day tshitadi! Yours sincerely Shared Services Connected Ltd – Delivering services in partnership with the Metropolitan Police Service Phone: 01633 632500 Email: Enquiries.PoliceJobs@police.sscl.com HCP Open Day with the MPS Inbox Dawn.James@met.police.uk Thu, Oct 24, 3:09 PM (3 days ago) to Dear Healthcare Professional, Thank you for registering your interest to attend our Healthcare Professional Open Day today at Charing Cross Police Station. Unfortunately you didn't attend, you can however still apply for the role by clicking on the link below, remember to attach a CV and personal statement. Become a custody healthcare practitioner | Metropolitan Police Please do contact me if you have any queries. Kind Regards Dawn Dawn James | Deputy Healthcare Director (Acting) Met Detention (M09) 07917 586675 | dawn.james@met.police.uk Lambeth HQ, 109 Lambeth Road, London, SE1 7LP NOTICE - This email and any attachments are solely for the intended recipient and may be confidential. If you have received this email in error, please notify the sender and delete it from your system. Do not use, copy or disclose the information contained in this email or in any attachment without the permission of the sender. Metropolitan Police Service (MPS) communication systems are monitored to the extent permitted by law and any email and/or attachments may be read by monitoring staff. Only specified personnel are authorised to conclude binding agreements on behalf of the MPS by email and no responsibility is accepted for unauthorised agreements reached with other personnel. While reasonable precautions have been taken to ensure no viruses are present in this email, its security and that of any attachments cannot be guaranteed. to me Dear Fiston, Thank you for applying for the position of Service Centre Helpdesk Coordinator - 33335. We appreciate the opportunity to consider you for employment with Eaton. This communication is to let you know that this job has been filled. We invite you to visit www.eaton.com/careers and apply to other opportunities that match your current career aspirations. Thank you for your continued interest in Eaton. Best regards, Tshingombe, will you answer a question for us? Inbox Schneider Electric Sat, Oct 26, 2:30 PM (21 hours ago) to me Hello Tshingombe, Recently, you applied and were considered for a position with Schneider Electric. While the outcome has not resulted in an offer of employment, we would appreciate your time in answering one final question which will help us understand your lasting impression of Schneider Electric. Our goal is to treat all candidates with fairness and respect and your lasting impression helps us understand if we have achieved our goal. Pulse - One Question Survey Thank you. We look forward to hearing from you! *Please note that all feedback is confidential and is not associated with any application. Any feedback gathered will not impact any potential employment with Schneider Electric. This email is being sent from an unmonitored email address. Schneider Electric can be reached at the following: 800 Federal Street North Andover, MA 01810 https://www.se.com/us/en/ / (978) 975-9600 Survale sends surveys on behalf of Schneider Electric at their request and has no involvement with employment decisions. We can be reached at contactus@survale.com. To unsubscribe click here Powered by Survale In Automatic reply: letter explanation theoretical pratical base work , n diplomat award engineering electrical Inbox CallCentre via dhetgovza.onmicrosoft.com 9:16 AM (8 hours ago) to me Please note that this is an automated response, do not reply to it. Thank you for contacting the Department of Higher Education and Training Call Centre. We appreciate your inquiry. Regarding NN Diploma, Nated, and NCV certificate enquiries: • All applications for new issues, replacements, or combination requests must be submitted directly to the relevant college. • Please note that there is a minimum waiting period of 3-6 months for diploma applications. • The issuance of NN Diploma is currently paused. We have communicated this to all colleges. • In the meantime, students whose diplomas are finalized but awaiting printing can obtain a confirmation letter from their college. We apologize for any inconvenience this may cause and appreciate your understanding. MMA support Inbox MMA Support via freshdesk.com Mon, Oct 21, 8:41 AM (2 days ago) to me Hi Tshingombe Thanks so much for reaching out! We know there's nothing worse than sending an email and getting no response. So, to make sure that you know that we are aware of your email, we have created this handy auto-reply just to let you know that we have your email and we are assigning it to the best person to help you! We like to be quite speedy on our replies, so you should get a response soon. Your experience is our first priority and our agents are here from Monday to Saturday between 08h00 and 20h00 and on Sundays between 08h00 and 19h00. You can also chat with our agents directly using our live chat on the Shoprite app. In the meantime, if you have general questions about the Money Market Account, check out our website for some handy walk-throughs and answers to some questions you may have. We have also created some useful videos on how to use the Money Market Account, please click here to view them. If you have any additional information that you think will help us to assist you, please feel free to reply to this email. We look forward to chatting soon! Money Market Account Services Team (no subject) Inbox Ahmed Abdelmonem (International Supplier) Tue, Oct 22, 1:52 PM (1 day ago) to me Hi Tshingombe, I trust this email finds you in good health. My name is Ahmed Abdelmonem, and I serve as a Customer Lifecycle Manager for Microsoft. My responsibilities include overseeing the SMB segment in the South African market. Within my role, I manage various Microsoft workloads, including: • Microsoft Azure: Our expansive cloud platform that provides an array of services tailored for the development, deployment, and management of applications. • Microsoft Dynamics: An integrated suite of ERP and CRM software applications designed to streamline business processes. • Modern Workplace: A collection of solutions aimed at enhancing collaboration and productivity within today's digital-first work environment. • Copilot: Our latest AI-driven platform that assists in code generation and other complex tasks, ensuring efficiency and innovation. I would like to connect with you to discuss your needs and explore the best possible solutions for your organization. Please let me know a convenient time for us to connect. Thank you for your attention, and I look forward to connecting with you soon. Regards, Ahmed Abdelmonem Customer Lifecycle Manager | SMB South Africa | MEA v-ahmabdelmo@microsoft.com Application Unsuccessful Inbox SARS Human Capital and Development Sat, Oct 26, 9:00 AM (1 day ago) to me Dear Tshingombe Tshitadi , Thank you for applying for Specialist Advisor: Direct Tax (Legal and Domestic Tax). After careful consideration and review of your profile against the minimum requirements (qualifications and work experience) of the job, we regret to inform you that your application was not successful. We encourage you to visit our career site and search other available opportunities. Thank you for showing interest and we wish you all the best in your job search. Thank you for applying to Schneider Electric! Inbox Schneider Electric Unsubscribe Sat, Oct 26, 5:22 AM (1 day ago) to me Hi Tshingombe, We appreciate your interest in career opportunities at Schneider Electric! Thank you for taking the time to apply for the Senior Power Electronics Architect position we have posted online. One of our Talent Acquisition Professionals will review your submission and contact you either by phone or email if you are selected to move forward in the process. We will make every attempt to complete this initial review within 10 – 15 business days; however, we ask for your understanding if it takes slightly longer due to high volumes. At Schneider Electric, we desire to provide reasonable transparency throughout the process. During the application process, you created an account in which you can log-in to check the status of your application at any time. You can also use this account to update and strengthen your profile. Thank you, The Schneider Electric Talent Acquisition Team Access My Career Portal Search for Jobs It is the policy of Schneider Electric to provide equal employment and advancement opportunities in the areas of recruiting, hiring, training, transferring and promoting all qualified individuals regardless of race, religion, color, gender, disability, national origin, ancestry, age, military status, sexual orientation, marital status, or any other legally protected characteristic or conduct. ____ This message was sent to tshingombefiston@gmail.com. If you don't want to receive these emails from this company in the future, please go to: https://se.icims.com/icims2/?r=6EA61614346& contactId=5749653&pid=17 © Schneider Electric Schneider Electric Sat, Oct 26, 5:26 AM (1 day ago) to me Hi Tshingombe, We appreciate your interest in career opportunities at Schneider Electric! 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 18 of 18 Thank you for taking the time to apply for the Digital Power Inside Sales Manager position we have posted online. One of our Talent Acquisition Professionals will review your submission and contact you either by phone or email if you are selected to move forward in the process. We will make every attempt to complete this initial review within 10 – 15 business days; however, we ask for your understanding if it takes slightly longer due to high volumes. At Schneider Electric, we desire to provide reasonable transparency throughout the process. During the application process, you created an account in which you can log-in to check the status of your application at any time. You can also use this account to update and strengthen your profile. Thank you, The Schneider Electric Talent Acquisition Team Access My Career Portal Search for Jobs It is the policy of Schneider Electric to provide equal employment and advancement opportunities in the areas of recruiting, hiring, training, transferring and promoting all qualified individuals regardless of race, religion, color, gender, disability, national origin, ancestry, age, military status, sexual orientation, marital status, or any other legally protected characteristic or conduct. ____ This message was sent to tshingombefiston@gmail.com. If you don't want to receive these emails from this company in the future, please go to: https://se.icims.com/icims2/?r=6EA61614346&contactId=5749656&pid=17 © Schneider Electric Schneider Electric Sat, Oct 26, 5:27 AM (1 day ago) We appreciate your interest in career opportunities at Schneider Electric! Thank you for taking the time to apply for the EcoStruxure Automation Expert Regional Schneider Electric Sat, Oct 26, 5:29 AM (1 day ago) to me Hi Tshingombe, We appreciate your interest in career opportunities at Schneider Electric! Thank you for taking the time to apply for the Energy Sourcing Analyst (Italian speaking) -Maternity Cover position we have posted online. One of our Talent Acquisition Professionals will review your submission and contact you either by phone or email if you are selected to move forward in the process. We will make every attempt to complete this initial review within 10 – 15 business days; however, we ask for your understanding if it takes slightly longer due to high volumes. At Schneider Electric, we desire to provide reasonable transparency throughout the process. During the application process, you created an account in which you can log-in to check the status of your application at any time. You can also use this account to update and strengthen your profile. Thank you, The Schneider Electric Talent Acquisition Team Tshingombe Tshitadi Dashboard | Log Out My Career Account Options shown include to update your full profile (helps get important information to our recruiting team), current and past application submissions with current status as well as managing subscription preferences to our talent communities. How can I correct my Personal Information? No need to wait for us, you own and are empowered to correct your data at any time. Just click on 'Update My Profile' and correct the information. Options Update My Profile View Current Job Opportunities Manage My Interests My Rights Submissions All times are in Eastern European Standard Time. Each row is an application to a Job. The last column contains buttons for actions such as withdrawing or continuing an application if applicable. ID Title Status Last Update Actions 2023-62576 Energy Sourcing Analyst (Italian speaking) - Maternity Cover Received Submission 10/25/2024 2023-55706 EcoStruxure Automation Expert Regional Consultant Received Submission 10/25/2024 2024-79748 Digital Power Inside Sales Manager Received Submission 10/25/2024 2024-79405 Senior Power Electronics Architect Received Submission 10/25/2024 2024-79092 Power Systems Medium Voltage Intern Not Selected 10/23/2024 Privacy Notice Schneider Electric Community About Fiston Tshingombe Fiston Company : Tshingombe Engineering engineering electrical st peace college diploma , Cadet Online Community Badges View All 2 Posts 0 Likes Received 0 Likes Given 0 Solutions MY ACTIVITY BOOKMARKS SUBSCRIPTIONS DRAFTS Go to mySchneider Translate to: Please select 1 Help Feedback About Fiston - Schneider Electric Community https://community.se.com/t5/user/viewprofilepage/user-id/153387 1 of 3 10/17/2024, 12:05 PM No Content Available My Content Likes Given Latest Contributions Activity Feed 0 0 0 0 0 0 0 2 My Moderated Posts Understanding Our Pre-Moderation Process: Fostering a Positive Community Environment My Photos Upload An Image Top Tags english scada SCADA software SCADA tutorial SCADA app Telemetry and SCADA ups apc battery smart-ups PowerChute back-ups turkish power shutdown firmware bug Indonesian modbus spacelynk management network software beeping edc communication homelynk NMC network_management_card problem View All Feedback About Fiston - Schneider Electric Community https://community.se.com/t5/user/viewprofilepage/user-id/153387 2 of 3 10/17/2024, 12:05 PM Terms & Conditions Privacy Notice Change your cookie settings © 2024 Schneider Electric, Inc FORUMS KNOWLEDGE CENTER EVENTS & WEBINARS IDEAS BLOGS GET STARTED | | Feedback About Fiston - Schneider Electric Community https://community.se.com/t5/user/viewprofilepage/user-id/153387 3 of 3 10/17/2024, 12:05 PM Thank you for your interest in Microsoft! Inbox Microsoft Recruiting Unsubscribe Fri, Oct 25, 5:10 PM (2 days ago) to me Hi Fiston Tshingombe teodor, Thank you for your interest in a career at Microsoft. Unfortunately, we will not be moving forward with your candidacy for the position of Software Engineer II, 1755381 at this time. However, we'd like to encourage you to continue to explore other career opportunities on Microsoft Careers as we continually update openings on a daily basis. We look forward to considering you for other positions at Microsoft! Thank you, Microsoft Recruiting Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. This mail is sent from an unmonitored mailbox. Please do not reply. Your Application to Schneider Electric - Tshingombe Tshitadi Inbox Schneider Electric Unsubscribe 2:17 PM (2 hours ago) to me Hi Tshingombe, Thank you again for your interest in Schneider Electric and the Power Systems Medium Voltage Intern role we have on our team. We wanted to follow-up on the status of your candidacy. Your application was impressive; however, you were not selected to continue forward in the process. Please do not take this decision to mean we have no interest in you as a candidate. We will keep your resume in our system and share opportunities that fit your skills and experience. New positions are posted daily, so we encourage you to continue visiting our career website but also sign-up for our talent pool emails to receive notification of the latest roles that match your profile. We wish you success in your job search and hope we will have the chance to consider you for another role in the future. Best regards, Brock Coffey The Schneider Electric Talent Acquisition Team Access My Career Portal Search for Jobs ____ This message was sent to tshingombefiston@gmail.com. If you don't want to receive these emails from this company in the future, please go to: https://se.icims.com/icims2/?r=6EA61614346&contactId=5716766 © Schneider Electric Update on Your Job Application for (644) Team Leader - Food and Beverages - CSD Inbox SARB Talent Acquisition 2:30 PM (2 hours ago) to me Dear tshitadi tshingombe, Thank you for your application to (644) Team Leader - Food and Beverages - CSD (644). Kindly note that this requisition hiring process currently on hold. Hence selection process will be paused temporarily, we will notify you as soon as we resume this process. Regards, SARB Talent Acquisition Team Update on your Job application with SARB SARB Talent Acquisition 2:35 PM (2 hours ago) Dear tshitadi tshingombe, Thank you for your interest in the (644) Team Leader - Food and Beverages - CSD at the SARB, we regret to inform you that your application was unsuccessful. Thank you for your interest in Microsoft! Inbox Microsoft Recruiting Unsubscribe 9:29 AM (7 hours ago) to me Hi Fiston Tshingombe teodor, Thank you for your interest in a career at Microsoft. Unfortunately, we will not be moving forward with your candidacy for the position of Senior Applied AI Engineer , 1762298 at this time. However, we'd like to encourage you to continue to explore other career opportunities on Microsoft Careers as we continually update openings on a daily basis. We look forward to considering you for other positions at Microsoft! Thank you, Microsoft Recruiting Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. This mail is sent from an unmonitored mailbox. Please do not reply. 11 of 8,039 Application Unsuccessful Inbox SARS Human Capital and Development 8:30 AM (8 hours ago) to me Dear Tshingombe Tshitadi , Thank you for applying for Researcher: Tariff X2. After careful consideration and review of your profile against the minimum requirements (qualifications and work experience) of the job, we regret to inform you that your application was not successful. We encourage you to visit our career site and search other available opportunities. Thank you for showing interest and we wish you all the best in your job search. Best Regards, SARS Talent Acquisition Team 23 October 2024 SARS Human Capital and Development 10:30 AM (6 hours ago) to me Dear Tshingombe Tshitadi , Thank you for applying for Technical Officer: Tariff Classification. After careful consideration and review of your profile against the minimum requirements (qualifications and work experience) of the job, we regret to inform you that your application was not successful. SARS Human Capital and Development 10:30 AM (6 hours ago) to me Dear Tshingombe Tshitadi , Thank you for applying for Investigator: Digital Fraud. After careful consideration and review of your profile against the minimum requirements (qualifications and work experience) of the job, we regret to inform you that your application was not successful. Update Around Your Application Inbox Eaton TalentHub Tue, Oct 22, 2:43 PM (1 day ago) to me Dear Fiston, Thank you for applying for the position of Commercial Finance Manager - 31056. We appreciate the opportunity to consider you for employment with Eaton. This communication is to let you know that this job has been filled. We invite you to visit www.eaton.com/careers and apply to other opportunities that match your current career aspirations. Thank you for your continued interest in Eaton. Best regards, Eaton TalentHub Tue, Oct 22, 3:47 PM (1 day ago) to me Dear Fiston, Thank you for applying for the position of Service Centre Helpdesk Coordinator - 33335. We appreciate the opportunity to consider you for employment with Eaton. This communication is to let you know that this job has been filled. We invite you to visit www.eaton.com/careers and apply to other opportunities that match your current career aspirations. Thank you for your continued interest in Eaton. Best regards, Please tell us the name of the officer or member of staff you are working with in relation to this request Become a Member My Elektor Topics Magazine Articles News Video Projects Newsletter Submit Store You are now logged in. MyLAB EN0202272ID No bio 0 | Follow user View as visitor: My Groups Coming soon My Stats 0 Published projects Views 0 Followers 0 Star(s) on average 0 Comments 0 Comments My Projects No projects Following Not following any project Subscribe to the e-zine Elektor is an international platform for applied electronics, providing engineers, makers, and startups with expert content, practical knowledge, and industry insights. Since the 1960s, we've empowered a global community to design, build, and share real-world solutions. Members get exclusive project access, store discounts, and opportunities to collaborate with top innovators. Whether you're learning, designing, or scaling a business, Elektor helps you connect, create, and grow. Become a member CUSTOMER SERVICE Privacy Policy Terms of business Copyright Contact us Advertising info ELEKTOR WORLD About Elektor Elektor MAGAZINE Elektor LABS Elektor STORE Submit Your Content Social Media Safe Payments BECOME FREE MEMBER AND RECEIVE OUR EZINE THE ELEKTOR UNIVERSE Become a Member My Elektor Topics Magazine Articles News Video Projects Newsletter Submit Store Elektor Account My Account My Address Details My Membership My PDF's & Courses My Projects My tag alert preferences My Newsletter preferences My Loyalty Coupons Logout My Account Avatar Upload your profile picture here JPEG, PNG or GIF file - 5 MB file size limit (please note this picture may be used with your online publications on our websites). Gender First Name Last Name Nickname Date of Birth My DVD settings Email address tshingombefiston@gmail.com Primary Add email address Invoice emailaddress Phone numbers Add phone number Change password Subscribe to the e-zine Elektor is an international platform for applied electronics, providing engineers, makers, and startups with expert content, practical knowledge, and industry insights. Since the 1960s, we've empowered a global community to design, build, and share real-world solutions. Members get exclusive project access, store discounts, and opportunities to collaborate with top innovators. Whether you're learning, designing, or scaling a business, Elektor helps you connect, create, and grow. Become a member CUSTOMER SERVICE Privacy Policy Terms of business Copyright Contact us Advertising info ELEKTOR WORLD About Elektor Elektor MAGAZINE Elektor LABS Elektor STORE Submit Your Content Social Media Safe Payments BECOME FREE MEMBER AND RECEIVE OUR EZINE THE ELEKTOR UNIVERSE Mains Power Outages Monitor Is Your Grid Supply Steadily Available? 8-Bit Companion for the Raspberry Pi Power Saving Made Easy Mercury Rectifiers PECULIAR Infographics Power & Energy Speed Control of a Brushed DC Motor EMF Measurement Instead of Tachogenerator 535B JANUARY & FEBRUARY BONUS EDITION 2025 | ELEKTORMAGAZINE.COM EDITION DIGITAL FOCUS ON Power & Energy 1 9 6 1 100k S I N C 240210-002 PIC GND OPI EXT D7a BZX84C2V7-TP C13 100n D1a BAS21 R9 4k7 R7 1k R8 EOne partner, unlimited technology solutions. fortec-integrated.de fortec-power.de • Embedded • HMI systems • Power supplies • Displays and TouchCONTENTS Elektor January/February 2025 Bonus Edition Elektor Magazine is published 8 times a year by Elektor International Media b.v. PO Box 11, 6114 ZG Susteren, The Netherlands Phone: +31 46 4389444 elektor.com | elektormagazine.com For all your questions service@elektor.com Become a Member elektormagazine.com/membership Advertising & Sponsoring Büsra Kas Tel. +49 (0)241 95509178 busra.kas@elektor.com elektormagazine.com/advertising Copyright Notice © Elektor International Media b.v. 2025 The circuits described in this magazine are for domestic and educational use only. All drawings, photographs, printed circuit board layouts, programmed integrated circuits, digital data carriers, and article texts published in our books and magazines (other than third-party advertisements) are copyright Elektor International Media b.v. and may not be reproduced or transmitted in any form or by any means, including photocopying, scanning and recording, in whole or in part without prior written permission from the Publisher. Such written permission must also be obtained before any part of this publication is stored in a retrieval system of any nature. Patent protection may exist in respect of circuits, devices, components etc. described in this magazine. The Publisher does not accept responsibility for failing to identify such patent(s) or other protection. The Publisher disclaims any responsibility for the safe and proper function of reader-assembled projects based upon or from schematics, descriptions or information published in or in relation with Elektor magazine. International Editor-in-Chief Jens Nickel Content Director C. J. Abate Publisher Erik Jansen C. J. Abate Content Director, Elektor Bonus Edition Power & Energy Solutions Looking for more power- and energy-related content? This bonus edition of ElektorMag features additional content to inspire you to design your own solutions. As usual, we include articles on other interesting topics as well. Is your grid supply steadily available? The article, "Mains Power Outages Monitor," details a circuit that constantly monitors mains power and signals outages. Before high-power semiconductor-based recti! ers, converting AC to DC in industrial and transportation applications was a signi! cant challenge. Devices were bulky, fragile, used polluting materials, and demanded frequent maintenance. Check out the article, "Mercury Recti! ers," to learn about mercury arc recti! ers and more. Brush-type DC motors are often replaced by brushless (BLDC) and stepper motors, but their simpler control still has advantages. The article, "Speed Control of a Brushed DC Motor," explores maintaining constant speed regardless of torque — without a tachometer generator. We hope you enjoy these articles and rest of the content in the Bonus edition. As you work on your own projects, be sure to document your progress on the Elektor Labs platform (www.elektormagazine.com/labs)! International Editor-in-Chief: Jens Nickel | Content Director: C. J. Abate | International Editorial Sta! : Asma Adhimi, Roberto Armani, Eric Bogers, JanBuiting, Rolf Gerstendorf (RG), Ton Giesberts, Saad Imtiaz, Alina Neacsu, Dr. Thomas Scherer, Jean-Francois Simon, Clemens Valens, Brian Tristam Williams | Regular Contributors: David Ashton, Stuart Cording, Tam Hanna, Ilse Joostens, Prof. Dr. Martin Ossmann, Alfred Rosenkränzer | Graphic Design & Prepress: Harmen Heida, Sylvia Sopamena, Patrick Wielders | Publisher: Erik Jansen | Technical questions: editor@elektor.com The Team COLOPHON EDITORIAL The January/ February 2025 edition of ElektorMag is available at newsstands and in the Elektor Store. 3 Colophon 4 Speed Control of a Brushed DC Motor EMF Measurement Instead of Tachogenerator 10 8-Bit Companion for the Raspberry Pi Power Saving Made Easy 12 From Life's Experience Micromanagement 14 Peculiar Parts Mercury Rectifiers 16 Infographics: Power and Energy 18 Mains Power Outages Monitor Is Your Grid Supply Steadily Available? January & February 2025 3 One partner, unlimited technology solutions. fortec-integrated.de fortec-power.de • Embedded • HMI systems • Power supplies • Displays and Touchgenerator unit is larger and more expensive than a tacholess version of a motor. If the motor is operated with a pulsed voltage (PWM), however, the speed is proportional to the duty cycle. At the same time, the motor operates as a generator in the off-phase of the PWM voltage so that its speed can be measured in this phase. In the past, in the analog age, the electronic effort for such a control was not insignificant, as can be seen from the schematic diagram in Figure 5. A rectangle generator, a voltage-controlled pulse width modulator, a sample-and-hold circuit to measure the actual speed value, and a PI controller were required. In the digital world, the principle remains the same, but the effort required is consid erably reduced thanks to the use of a microcontroller. By Rainer Schuster (Germany) Brush-type DC motors are increasingly being replaced by their brushless (BLDC) and stepper motor competitors. However, their use still makes some sense, as the control effort is considerably lower. This article shows how to keep the speed of a DC motor with brushes constant regardless of the torque – and without a tachometer generator. In the simplest case, a DC motor is connected to a variable voltage supply, as shown in Figure 1. The speed is (theoretically) propor tional to the supply voltage VM, but only as long as the torque is constant. Unfortu nately, the equivalent circuit diagram of the DC motor looks like Figure 2. The motor winding not only has an inductance LM, but also an ohmic resistance of the copper wire, which is designated by RM. The higher the torque, the more voltage drops across RM, until finally there is no more voltage across the inductance LM and the motor stops (Figure 3). Control with Tachogenerator or EMF Measurement To compensate for these torque-dependent speed fluctuations, the motor was once usually coupled to a tachogenerator, which in turn supplied a voltage proportional to the speed (Figure 4). However, a motor-tacho Speed Control of a Brushed DC Motor EMF Measurement Instead of Tachogenerator basics 4 Bonus Edition January & February 2025 www.elektormagazine.comRPM ~ VM M VM Figure 1: In an ideal world, the speed is proportional to the motor voltage. I ~ N V = V – R x I RPM ~ V L RM M M M M M M M M VM Figure 2: In practice, the ohmic resistance of the motor winding joins its inductance. U/min I M NM Figure 3: The higher the torque, the slower the motor turns. Rev. target value Differential amplifier Tacho generator Motor Voltage regulator Power supply M Figure 4: Block diagram of a motor control system with tachogenerator. PI-Regler Drehzahl Sollwert Sample & Hold-Schaltung MOSFET-Schalter Spannungsgesteuerter Pulsbreitenmodulator NF-Rechteck Generator Strom versorgung Motor M Figure 5: Block diagram of a motor control with EMF measurement. January & February 2025 5 Practical Implementation of an EMF Control As the complete circuit diagram in Figure 6 shows, an ATtiny45 microcon troller from Microchip with 4 kB of flash memory is used for control. The controller has only eight pins, but is perfectly suited for this application. It can be programmed "in system" via SV2 using an ISP program ming device. The microcontroller is supplied with 5 V by the voltage regulator IC2, which is why the input voltage (and thus the motor voltage) must not exceed 24 V. Q1 and Q2 control the motor. Q2 is a PMOS transistor of the type IRF4905, which can theoretically handle a motor current of 74 A, but only if a sufficiently dimensioned heat sink is used. Figure 7 shows what happens at the motor terminals during the different phases of the PWM signal: After the ON phase of the PWM signal, a demagnetization period follows in the OFF phase; then the motor generates an EMF voltage that is propor tional to the speed. This voltage is fed to the ADC2 analog-to-digital converter of the microcontroller via the R4/R5 voltage divider. R5 should be dimensioned so that the voltage at ADC2 does not exceed 5 V. VB R5 12 V 4k7 24 V 2k2 The setpoint speed, which is set by the RPM potentiometer or an external voltage of 0…5 V at X6, is sent to ADC1 of the micro controller. Diode D1 is absolutely neces sary because when the control voltage is switched off, the inductance of the motor discharges, which results in a negative voltage spike that D1 limits to about 0.7 V. Figure 8 shows a suggested printed circuit board layout for the motor control with EMF measurement; the required compo nents are listed in the Component List. Software I The software for the ATtiny45 was written in BASCOM. The controller is operated inter nally at 8 MHz. Timer0 is operated as a PWM timer in Phase Correct PWM Timer mode. Demagnetization Switch-o phase Switch-on phase Figure 7: The speed is measured in the switch-off phase after demagnetization. EMF = actual motor speed 240486-009 see text ISP RPM +5V +5V MOSI GND Reset SCK MISO +5V +24V max. +24V max. X2 Power PB5(RESET/ADC0) PB3(ADC3) PB2(SCK-ADC1) PB4(ADC2) PB1(MISO) PB0(MOSI) IC1 ATtiny45 GND VCC 4 1 2 3 8 7 6 5 1 3 5 2 4 6 SV1 C1 1n X1 C2 100n C3 100n Motor D1 1N4004 Q2 IRF4905 G D S R1 R2 47k R3 1M Q1 G S D BS170 R4 R5 IC2 78L05 C4 100n C5 100µ 35V R6 10k X3 C6 10µ 16V R7 Figure 6: Practical circuit of the EMF motor control. 6 Bonus Edition January & February 2025 www.elektormagazine.com 10k 10k 10kWith a prescaler of N = 64, the PWM frequency is: At 8 MHz, this results in a frequency of 245 Hz. The pulse width is set via register PWM0A from 0 to 255. Depending on the motor type, the prescaler may need to be set to 256, for example if the induction phase is longer than or the same length as the switch-off phase. This results in a PWM frequency of approxi mately 60 Hz. In the main program loop, the speed setpoint is constantly read in at ADC1. The actual value is read in at ADC2 during the off-phase (Pwm_Pin=0) and summed up. When the motor is switched on again, the average of the actual value is calculated. To implement the PI controller, there is the constant Ti (integration time), together with the time constant of Timer1 and Kp (proportional gain), which must be adapted to the motor used. The interrupt time of Timer1 is set using the TCCR1 register: TCCR1 Timer1 Interrupt 4 250 µs 5 500 µs 6 1 ms 7 2 ms When Ti has expired (Timer1-Interrupt × Ti), the speed deviation is calculated, added to the previous value (taking into account the sign) and multiplied by Kp. The result is output directly as the new switch-on duration. Control Using RI Compensation Another practical solution can be what is known as RI compensation. As mentioned at the beginning, the speed fluctuation of a DC motor is due to the ohmic resistance of its copper winding. If the current through the motor is measured, this resistance can be compensated. To do this, only the coil resistance of the motor needs to be known, which can be easily measured. The circuit in Figure 9 is similar to that in Figure 6, except that the motor current is measured as a voltage drop across R5. R5 is to be dimensioned so that a maximum of 0.5 V is dropped across R5 at maximum motor current. The power dissipation in watts must be equal to R5 × motor current squared. Figure 10 shows a suggested layout for the motor control with RI compensation. 1 6 C1 C2 C3 C4 R3 R4 R5 SV1 C5 C6 R1 R7 1 n 1 00n 1 00n 1 00n 1 M 1 0k TINY45 1 00u/35 1 0u/1 6 1 0k 1 0k Figure 8: Proposal for a circuit board layout for the EMF control. 1 6 C1 C2 C3 C4 R1 R3 R5 SV1 C5 C6 R7 1 n 1 00n 1 00n 1 00n 1 0k 1 M TINY45 1 00u/35 1 0u/1 6 1 0k Figure 10: Proposed circuit board layout for the control with RI compensation. Figure 9: The motor control with RI compensation differs only in one detail. 240486-009 see text ISP RPM +5V +5V MOSI GND Reset SCK MISO +5V +24V max. +24V max. X2 Power PB5(RESET/ADC0) PB3(ADC3) PB2(SCK-ADC1) PB4(ADC2) PB1(MISO) PB0(MOSI) IC1 ATtiny45 GND VCC 4 1 2 3 8 7 6 5 1 3 5 2 4 6 SV1 C1 1n X1 C2 100n C3 100n Motor D1 1N4004 Q2 IRF4905 G D S R1 R2 47k R3 Q1 G S D BS170 R4 R5 IC2 78L05 C4 100n C5 100µ 35V R6 10k X3 C6 10µ 16V Software II The software for the RI compensation is also written in BASCOM. Timer0 is config ured as a PWM timer with a frequency of 245 Hz. In contrast to the EMF control, the control here is designed as a pure P controller. To do this, the coil resistance of the motor and the supply voltage must be known and specified as constants RM and U0 in the program. The motor current is now measured during the switch-on phase of the PWM signal. The effective value of the current is calcu lated from the switch-on duration: The duty cycle is then increased by the corresponding value. Two Options There are several ways to control a DC motor without a tachogenerator. Each of these options has different advantages and disadvantages: > For the EMF control, a PI controller is required, the parameters of which January & February 2025 7 A1 7,5mm 1 2 1 2 - OI 1 2 3 D1 IC2 Q1 Q2 R2 X1 X2 X3 IC1 R6 1 N4004 78L05 BS1 70 IRF4905 47k 1 0k A1 7,5mm 1 2 1 2 - OI 1 2 3 D1 IC2 Q1 Q2 R2 X1 X2 X3 IC1 R4 1 N4004 78L05 BS1 70 IRF4905 47k 1 0k 10k 10k 10kmust be adapted to the motor used in order to optimize over- and under shoot. To do this, voltage fluctu ations in the supply voltage are compensated. > With RI compensation, there are no overshoots or undershoots, but voltage fluctuations in the supply voltage are not compensated. The schematics, layouts, and software for both controllers can be downloaded from the Elektor Labs project page at [1]. Translated by Jörg Starkmuth — 200486-01 About the Author Rainer Schuster 's fascination with electronics began at the age of 13, when he received the Philips EE1 electronics experiment kit from his parents for Christ mas in 1970. In September 1971, he bought his first issue of Elektor magazine and has remained loyal to it to this day. After study ing electrical engineering at the Munich University of Applied Sciences, he worked for 37 years as an engineer in electronics development at Agfa in Munich. He has been writing articles for Elektor since 2009. Now that he is retired, he also has his own YouTube channel (www.youtube. com/@rainerschuster5722), where he posts his projects. Questions or Comments? Do you have questions or comments about this article? Email the author at rainerschuster@mnet-mail.de, or contact Elektor at editor@elektor.com. Related Product > Motor Control Development Bundle www.elektor.com/20534 [1] Elektor Labs page about this project: https://tinyurl.com/200486-01 [2] YouTube video: https://www.youtube.com/watch?v=6IEVBQyKlF4 WEB LINKS Component List for RI Compensation Controller Resistors: R1, R6, R7 = 10 kΩ R2 = 47 kΩ R3 = 1 MΩ R5 = see text Capacitors: C1 = 1 nF C2…C4 = 100 nF C5 = 100 µF/35 V C6 = 10 µ/16 V Semiconductors: D1 = 1N4004 Q1 = BS170 Q2 = IRF4905 IC1 = ATtiny45 IC2 = 78L05 Miscellaneous: SV1 = 2 × 3-pin header X1,X2 = 2-pin PCB terminal, 5 mm pitch X3 = 3-pin PCB terminal, 5 mm pitch Component List for EMF Controller Resistors: R1, R4, R6, R7 = 10 kΩ R2 = 47 kΩ R3 = 1 MΩ R5 = see text Capacitors: C1 = 1 nF C2…C4 = 100 nF C5 = 100 µF/35 V C6 = 10 µF/16 V Semiconductors: D1 = 1N4004 Q1 = BS170 Q2 = IRF4905 IC1 = ATtiny45 IC2 = 78L05 Miscellaneous: SV1 = 2 × 3-pin header X1, X2 = 2-pin PCB terminal, 5 mm pitch X3 = 3-pin PCB terminal, 5 mm pitch 8 Bonus Edition January & February 2025 www.elektormagazine.com January & February 2025 9 LUCKY YOU! Not a subscriber yet? Sign up for our free e-zine newsletter at elektormagazine.com/ezine-24 LUCKY YOU! An e-zine subscriber never misses the monthly 'reverse project' GET FREE DOWNLOADDEVELOPER ZONE The MCU obviously requires a separate power supply that is independent of the EN input; due to the low-energy requirement, a linear regulator is the most economical solution here. In general, the concept is completely component-agnostic; the author likes to use modern PIC16F derivatives from Microchip. Figure 2 shows the sub-circuit that informs the PIC when the SBC (OPI = Orange Pi) is supplied by the external switching regulator (EXT). D1a, R9 and D7a implement a more or less "classic" attenuator, which breaks down input voltages in the range of up to 20 V to a value that is "manageable" for the inputs of process computer and microcontroller. Splitting the series resistor into the values R7 and R9 is necessary because single board computers sometimes become a low-impedance load or have a residual voltage when they are switched o" — without the resistor, this Single-board computers with Unix capability facilitate the development of complex control systems. Especially in scenarios with high demands on GUI and data process ing, they are superior to microcontrollers (MCUs). Unfortu nately, power consumption and real-time capability leave some room for improvement. But why not combine the best of both worlds? If you want to trim an o" -the-shelf single-board computer to be economical, you can achieve this with an eight-bitter as a partner. As an example, we want to implement a system that adheres to programmed downtimes and carries out an "alarm start" in response to a specific external event. The Circuit Concept In principle, the circuit works as shown in the flowchart (Figure 1). The voltage regulator acting as the main supply for the process computer (usually a switching regulator) is controlled by the microcontroller via its Enable input (EN). By Tam Hanna (Hungary) Raspberry Pis and other SBCs are ideal for sophisticated process control, but require signi! cantly more power than microcontrollers. Why not combine the best of both worlds? Here we show you how to get an 8-bit PIC to switch on a Raspberry Pi whenever it is needed. 8-Bit Companion for the Raspberry Pi Power Saving Made Easy Figure 1: This circuit design significantly reduces energy consumption in stand-by mode. Figure 2: The R7 resistor can save both costs and headaches. 240210-002 PIC GND OPI EXT D7a BZX84C2V7-TP C13 100n D1a BAS21 R9 4k7 R7 1k R8 10 Bonus Edition January & February 2025 www.elektormagazine.com 100kwould cause the power management microcontroller (connected via the PIC terminal) to see strange or invalid values. R7 is an additional protective element — the inputs of the process computer are connected to the supply voltage and ground via protective diodes. When very high voltage levels occur, R7 ensures that the current flowing into these diodes is limited and the process computer is not damaged — C13 and R8 provide a small additional debouncing function. It should be noted that the circuit shown here with its EXT input was connected "directly" to the vehicle electrical system in various school buses. As there are now several thousands of such systems on the market without failures, it has been proven to work. The role of diode D1a as reverse polarity protection is also helpful — please believe the author, who also works in the logistics sector, that connecting batteries the wrong way round is one of the classic "sports" of a mechanic. The Software Is the Key Communication via I2C is generally unproblematic (but don't forget the necessary pull-ups). The "secret" of this system lies in the software. The PIC implements a kind of state machine that is based on the states shown in Figure 3. The implementation of the shutdown process is of partic ular importance. Unixoid operating systems tend not to react very kindly to rough shutdowns. A convenient and practical way to solve the problem is to implement a countdown timer: The SBC activates this countdown and then starts the shutdown of the operating system. After the (generously dimensioned) period of time has elapsed, the process computer is "inertialized" and can be disconnected from the power supply. Of course, the PIC can also perform other tasks. In addition to storing serial numbers and other informa tion (in order to make it harder to manipulate), it is also possible, for example, to perform basic control tasks on the PIC. Of course, more complex implementations are also possible: A complex MSR task, for example, would make a 32-bit MCU appear reasonable as the second ary controller. Practical Experience Trackers based on the circuit concept shown here are now being used in tens of thousands by one of the author's

customers, demonstrating the practical value of the design. Instead of a stand-by power consumption of around 200 mA, the system now gets by with just a few milliamperes. The author's AN4121, published by Microchip, is available at [1] and provides further infor mation on the topic. Translated by Jörg Starkmuth — 240210-01 Questions or Comments? Do you have questions or comments about this article? Email the author at tamhan@tamoggemon.com or contact Elektor at editor@elektor.com. Figures: Ts Also helpful in the embedded sector: the state machine. [1] Tala Ganesh and Tam Hanna, "Using PIC16F Microcontrollers for System Power Supply Control," Microchip Application Note AN4121, 2021; https://www.microchip.com/en-us/application-notes/an4121 WEB LINK About the Author Ing. Tam Hanna has been working with electronics, computers, and software for more than 20 years; he is a freelance developer, book author, and journalist (www.instagram.com/tamhanna). In his spare time, Tam's interests include 3D printing and the distribution of cigars. January & February 2025 11DEVELOPER'S ZONE installation on the roof or engage in energy sharing with the owner of an installation at another location. For a communal instal lation, you need a two-thirds majority of the co-owners, good luck with that, I would say; as a tenant, you should try to convince your landlord eventually. And regarding energy sharing, that is hardly appealing because it is complex, cumbersome and above all expensive. It is possible to have a small PV installation in Belgium, but you have to follow the same procedures as for traditional larger installations. With a "xed connection to a separate group in the distri bution cabinet, the necessary inspections and bureaucracy, the costs rise considerably and your goal" to melt like snow in the sun. However, there is light at the end of the tunnel and from May 2025, plug-in solar panels would – "ually — be allowed in Belgium after all. The system, of course, is how strict the conditions and modalities will be. With a bit of bad luck, you will have to be able to present an inspection report of your electrical installation, and you run the risk of having a "smart" meter shoved down your throat. Belgians are rather risk-avoiding, and this is also reflected at the policy and regula tory level. In my opinion, it would be better to ban extension cords with a power strip, electric bikes, electric scooters and hover boards. These have been in the news several times in the context of house "res and with the last two devices, you can have serious accidents too. I was reminded of this after last summer's commotion around a well-known Belgian DIY store that had o$ ered plug-in solar panels with the best of intentions but had to remove them from its shelves again, to its shame. Speed Camera While in neighbouring countries "plug-in solar panels" have been used trouble-free for years (Figure 1), a Belgian user organi zation and sector federation for renewable energy ODE — apart from the fact that it is forbidden — seem to be particularly disliking of balcony PV installations [3]. According to them, these are potentially unsafe, which may have a short lifes pan, and hardly financially interesting for larger installations. They have a clear preference for "xed installations that can only be installed and commissioned by a licensed installer. Quoted by Dr. Thomas Scherer [1] [2], and Elektor's resident expert on the ideas of covering your home's "quiescent power consumption" with solar energy. In Germany, you even get a subsidy for this; but unfortunately, I live in Belgium where this kind of installation is strictly forbidden by Synergrid technical regulation C10/11 due to — alleged — "re and electrocution danger. From Life's Experience Micromanagement Source: Adobe Stock / EtiAmmos. developer's zone 12 Bonus Edition January & February 2025 www.elektormagazine.com Tips & Tricks, Best Practices and Other Useful InformationDEVELOPER'S ZONE heating systems and which car we drive. Similarly, the sale of numerous "hazard ous" substances to individuals has been restricted. Even lead-based solder is becom ing harder and harder to "nd, and there are already suppliers in Europe that no longer sell this stu$ to individuals because it contains lead. Just imagine working on older electronic equipment for the hobby. This kind of micromanagement also curtails entrepreneurship because many companies start small, perhaps as a few students who have discovered a gap in the market and are working on a garage (Figure 2). But given the current EU legislation, they will have to comply with the same gamut of rules as a pharmaceutical company and, as far as I am concerned, that has to be expanded and 24 to Dude more criteria. I dare to plead for less interference, fewer and clearer regulations and, above all, more juridical certainty. Nobody can be against that. Translated by Hans Adams — 240608-01 Politicians usually have a legal background and within that education one appar ently sees no point in ill-considered ad hoc legislation. They just act according to the delusion of the day or based on #ash politics, resulting in unclear "# ip-# op legis lation." Premiums for electric cars have already been introduced and abolished twice, and because of twists and turns in the law, users of electric company cars who charge them at home will soon be allowed to pay a lot more taxes. Belgium does not have a monopoly on absurdities, and in the Netherlands I hear rumours about grid operators secretly increasing the voltage taps on district transformers to limit feed-in from solar panels. In Zeeland, an expert ment has even started where homeowners are asked to switch o$ their solar panels on sunny days for a fee. It shouldn't get any crazier after years of pushing people to install solar panels anyway. Perhaps the government is now considering that the "nancial incentive for solar panels has been paid out long enough and that it is time to collect the money back with that tari$, your smart meter becomes more like a speed camera that mercilessly charges you every time you have a few too many devices powered on at once in a moment of inattention. And the regulation on the roll-back counter, from which owners with solar panels could bene" t for another 15 years, was rejected by the Constitutional Court in 2021 because the Flemish government had gone beyond its authority. After "erce protests, the same government was obliged to compensate the duped owners of solar panels. Flipflop You will no doubt be familiar with mathematician and computer scientist Edsger Dijkstra [4] who took issue with the excessive use of goto instructions in higher programming languages [5]. During my training, the ban on goto instructions was enforced to avoid an untidy "spaghetti code." [1] Dr. Thomas Scherer, "Balcony Power Plant," Elektor 9-10/2021: https://www.elektormagazine.com/magazine/elektor-183/59831 [2] Dr. Thomas Scherer, "Optimizing Balcony Power Plants," Elektor 1-2/2024: https://www.elektormagazine.com/magazine/elektor-324/62631 [3] VRT nws: Are Asda Commons, https://www.vrt.be/vrtnws/nl/2022/06/15/asda-stampfgleichrichter_in_Berlin-JPG/ Ignitor Electrode Ignition has to be started by an ignitor electrode, which usually has to briefly come into contact with the mercury. This is done by a number of means, including electromagnets, metallic strips, etc. Once the arc has been struck to cause mercury vapor to form, rectification can take place. Most mercury-arc rectifiers were 3 or 6-phase, but single-phase recti fiers needed an excitation electrode to keep the process going. The whole assembly is built within a large glass bulb, which allows the 14 Bonus Edition January & February 2025 www.elektormagazine.comFigure 2: Functional schematic of a mercury-arc rectifying tube (Source: Wikimedia commons, https://commons.wikimedia.org/w/index. php?curid=4577899) mercury vapor to condense and flow back to the cathode pool. The construction of a typical rectifier is shown in Figure 2. A typical 6-phase, 150 A rectifier was around 600 mm tall and about 300 mm round. Above 500 A steel tanks were used with ceramic insula tors for the electrodes, and these were rated up to several thousand amps. Ratings up to several kV were available, higher with special construction techniques, but these required frequent maintenance. The mercury ans emit a lot of ultraviolet light, you could get sunburned while working around them. Additionally, the noise from them and indi vidual transformers was considerable. Mercury is highly toxic and extensive clean-up work is often needed to remove traces of mercury when decommissioning them. 240624-01 Questions or Comments? If you have technical questions or comments about this article, feel free to contact the Elektor editorial team by email at editor@elektor.com. About the Author David Ashton was born in London, grew up in Rhodesia (now Zimbabwe), lived and worked in Zimbabwe, and now lives in Australia. He has been interested in electronics since he was "knee-high to a grasshopper." Rhodesia was not the center of the electronics universe, so adapting, substituting, and scrounging components were skills he acquired early (and still prides himself on). He has run an electronics lab, but has worked mainly in telecommunications. They trust us, do you? We love electronics and projects, and we do our utmost to fulfill the needs of our customers. The Elektor Store: 'Never Expensive, Always Surprising!' Check out more surprising products in the Elektor Store! www.elektor.com/store Or www.elektor.com/store Or visiting our Elektor Store! Elektor Store! Elektor Store!

11/21/2023 Badge Integrate content with Power BI client APIs Completed on 11/21/2023 Badge Embed Power BI content Completed on 11/21/2023 Badge Set up permissions to embed Power BI content Completed on 11/21/2023 Badge Select a Power BI embedded analytics product Completed on 11/21/2023 Badge Introduction to Power BI embedded analytics Completed on 11/21/2023 Badge Assess and convert SQL Server databases using the Data Migration Assistant (DMA) Completed on 11/20/2023 Badge SQL Server Discovery using the Microsoft Assessment and Planning (MAP) toolkit Completed on 11/20/2023 Badge Introduction to upgrading SQL Server Completed on 11/20/2023 Badge Use the SQL Server Query Tuning Assistant Completed on 11/20/2023 Badge Test and optimize SQL Server databases using the Database Experimentation Assistant (DEA) Completed on 11/20/2023 Badge Assess SQL Server databases for migration to Azure SQL Completed on 11/20/2023 Badge Design a SQL Server migration strategy Completed on 11/20/2023 Badge Migrate SQL workloads to Azure Managed Instances Completed on 11/20/2023 Badge Migrate SQL Server workloads to Azure SQL Database Completed on 11/20/2023 Badge Migrate on-premises workloads to Azure Completed on 11/20/2023 Badge Prepare on-premises workloads for migration to Azure Completed on 11/20/2023 Badge Design your migration to Azure Completed on 11/20/2023 Badge Migrate VMware resources on-premises to Azure VMware Solution Completed on 11/20/2023 Badge Prepare to migrate VMware resources to Azure by deploying Azure VMware Solution Completed on 11/20/2023 Badge Introduction to Azure VMware Solution Completed on 11/20/2023 Badge Using Azure NetApp Files with Azure VMware Solution Completed on 11/20/2023 Badge Secure outbound internet connectivity for Azure VMware Solution Completed on 11/20/2023 Badge Deploy disaster recovery using VMware Site Recovery Manager and Azure VMware Solution Completed on 11/20/2023 Badge Implement business continuity, disaster recovery, and backup for SAP HANA on Azure (Large Instances) Completed on 11/20/2023 Badge Monitor and troubleshoot SAP HANA on Azure (Large Instances) Completed on 11/20/2023 Badge Manage SAP HANA on Azure (Large Instances) Completed on 11/20/2023 Badge Implement and deploy SAP HANA on Azure (Large Instances) Completed on 11/20/2023 Badge Examine backup security licensing and support considerations for SAP HANA on Azure (Large Instances) Completed on 11/20/2023 Badge Plan SAP HANA on Azure (Large Instances) high availability and disaster recovery Completed on 11/20/2023 Badge Plan SAP HANA on Azure (Large Instances) deployments Completed on 11/20/2023 Badge Examine SAP HANA on Azure (Large Instances) sample architecture Completed on 11/20/2023 Badge Identify SAP HANA on Azure (Large Instances) certified offerings Completed on 11/20/2023 Badge Design data integration Completed on 11/20/2023 Badge Design a data storage solution for relational data Completed on 11/20/2023 Badge Design a data storage solution for non-relational data Completed on 11/20/2023 Badge Scope report design requirements Completed on 11/20/2023 Badge Manage Power BI assets by using Microsoft Purview Completed on 11/20/2023 Badge Catalog data artifacts by using Microsoft Purview Completed on 11/20/2023 Badge Discover trusted data using Microsoft Purview Completed on 11/20/2023 Badge Introduction to Microsoft Purview Completed on 11/20/2023 Badge Integrate Microsoft Purview and Azure Synapse Analytics Completed on 11/20/2023 Badge Use Delta Lake in Azure Synapse Analytics Completed on 11/20/2023 Badge Transform data with Spark in Azure Synapse Analytics Completed on 11/20/2023 Badge Analyze data with Apache Spark in Azure Synapse Analytics Completed on 11/20/2023 Badge Challenge project - Create Microsoft Power Platform solutions Completed on 11/20/2023 Badge Design a semantic model in Power BI Completed on 11/20/2023 Badge Choose a Power BI model framework Completed on 11/20/2023 Badge Describe Power BI Desktop models Completed on 11/20/2023 Badge Optimize a model for performance in Power BI Completed on 11/20/2023 Badge Add calculated tables and columns to Power BI Desktop models Completed on 11/20/2023 Badge Add measures to Power BI Desktop models Completed on 11/20/2023 Badge Write DAX formulas for Power BI Desktop models Completed on 11/20/2023 Badge Clean, transform, and load data in Power BI Completed on 11/20/2023 Badge Get data in Power BI Completed on 11/20/2023 Badge Explore data analytics at scale Completed on 11/20/2023 Badge Understand concepts of data analytics Completed on 11/20/2023 Badge Explore Azure data services for modern analytics Completed on 11/20/2023 Badge Secure data and manage users in Azure Synapse serverless SQL pools Completed on 11/20/2023 Badge Create a lake database in Azure Synapse Analytics Completed on 11/20/2023 Badge Use Azure Synapse serverless SQL pools to transform data in a data lake Completed on 11/20/2023 Badge Use Azure Synapse serverless SQL pool to query files in a data lake Completed on 11/20/2023 Badge Load data into a relational data warehouse Completed on 11/20/2023 Badge Analyze data in a relational data warehouse Completed on 11/20/2023 Badge Secure a data warehouse in Azure Synapse Analytics Completed on 11/20/2023 Badge Manage and monitor data warehouse activities in Azure Synapse Analytics Completed on 11/20/2023 Badge Design a Modern Data Warehouse using Azure Synapse Analytics Completed on 11/20/2023 Badge Explore Azure Synapse Studio Completed on 11/20/2023 Badge Survey the Components of Azure Synapse Analytics Completed on 11/20/2023 Badge Introduction to Azure Synapse Analytics Completed on 11/20/2023 Badge Introduction to Azure Data Lake Storage Gen2 Completed on 11/20/2023 Badge Introduction to data engineering on Azure Completed on 11/20/2023 Badge Build a Power Apps component Completed on 11/20/2023 Badge Introduction to Dataverse for developers Completed on 11/20/2023 Badge Extend plug-ins in Power Platform Completed on 11/20/2023 Badge Apply basic performance optimization in finance and operations apps Completed on 11/20/2023 Badge Build workspaces in finance and operations apps Completed on 11/20/2023 Badge Build reports for finance and operations apps Completed on 11/20/2023 Badge Create classes in finance and operations apps Completed on 11/20/2023 Badge Build forms and optimize form performance in finance and operations apps Completed on 11/20/2023 Badge Build data models in finance and operations apps Completed on 11/20/2023 Badge Build extended data types and enumerations for finance and operations apps Completed on 11/20/2023 Badge Develop object-oriented code in finance and operations apps Completed on 11/20/2023 Badge Get started with development using X++ in finance and operations apps Completed on 11/20/2023 Badge Start developing for finance and operations apps by using Visual Studio Completed on 11/20/2023 Badge Set up a VHD for finance and operations apps Completed on 11/20/2023 Badge Configure Azure App Service Completed on 11/20/2023 Badge Configure Azure App Service plans Completed on 11/20/2023 Badge Configure virtual machine availability Completed on 11/20/2023 Badge Configure virtual machines Completed on 11/20/2023 Badge Host a web application with Azure App Service Completed on 11/20/2023 Badge Manage virtual machines with the Azure CLI Completed on 11/20/2023 Badge Configure Azure Container Instances Completed on 11/20/2023 Badge Enable Containers security Completed on 11/20/2023 Badge Configure and manage host security Completed on 11/20/2023 Badge Configure network security Completed on 11/20/2023 Badge Implement perimeter security Completed on 11/20/2023 Badge Microsoft Accessibility Features and Tools Completed on 11/20/2023 Badge Introduction to disability and accessibility Completed on 11/20/2023 Badge Digital accessibility Completed on 11/20/2023 Badge Creating accessible content with Microsoft 365 Completed on 11/20/2023 Badge Introduction to Teams Meetings Completed on 11/20/2023 Badge Bringing it all together for engaging virtual events in Microsoft 365 Completed on 11/20/2023 Badge Design a successful virtual event using Microsoft 365 Completed on 11/20/2023 Badge Introduction to delivering virtual events using Microsoft Teams and Microsoft 365 Completed on 11/20/2023 Badge Introduction to collaborating with Microsoft Teams Completed on 11/20/2023 Badge Facilitate meetings and events with Microsoft Teams Completed on 11/20/2023 Badge Collaborate in teams and channels with Microsoft Teams Completed on 11/20/2023 Badge Create and manage teams and channels with Microsoft Teams Completed on 11/20/2023 Badge Describe support offerings for Microsoft 365 services Completed on 11/20/2023 Badge Describe Microsoft 365 pricing, licensing, and billing options Completed on 11/20/2023 Badge Explore Azure Functions Completed on 11/20/2023 Badge Develop Azure Functions Completed on 11/20/2023 Badge Make recommendations with Azure AI Personalizer Completed on 11/20/2023 Badge Classify and moderate text with Azure Content Moderator Completed on 11/20/2023 Badge Support reading fluency practice with Reading Progress Completed on 11/20/2023 Badge Introduction to Azure Logic Apps Completed on 11/20/2023 Badge Create and deploy an Azure Logic Apps workflow using Azure Resource Manager templates Completed on 11/20/2023 Badge Call an API from an Azure Logic Apps workflow using a custom connector Completed on 11/20/2023 Badge Route and process data automatically using Azure Logic Apps Completed on 11/20/2023 Badge Create serverless logic with Azure Functions Completed on 11/20/2023 Badge Expose hybrid services securely with Azure Relay Completed on 11/20/2023 Badge Implement message-based communication workflows with Azure Service Bus Completed on 11/20/2023 Badge Choose a messaging model in Azure to loosely connect your services Completed on 11/20/2023 Badge React to state changes in your Azure services by using Event Grid Completed on 11/20/2023 Badge Enable reliable messaging for Big Data applications using Azure Event Hubs Completed on 11/20/2023 Badge Communicate between applications with Azure Queue storage Completed on 11/20/2023 Badge Work with Azure Blob storage Completed on 11/20/2023 Badge Manage the Azure Blob storage lifecycle Completed on 11/20/2023 Badge Explore Azure Blob storage Completed on 11/20/2023 Badge Explore Azure App Service deployment slots Completed on 11/20/2023 Badge Scale apps in Azure App Service Completed on 11/20/2023 Badge Configure web app settings Completed on 11/20/2023 Badge Explore Azure App Service Completed on 11/20/2023 Badge Design a solution for backup and disaster recovery Completed on 11/19/2023 Badge Describe high availability and disaster recovery strategies Completed on 11/19/2023 Badge Implement canary releases and dark launching Completed on 11/19/2023 Badge Implement blue-green deployment and feature toggles Completed on 11/19/2023 Badge Introduction to deployment patterns Completed on 11/19/2023 Badge Manage application configuration data Completed on 11/19/2023 Badge Integrate with identity management systems Completed on 11/19/2023 Badge Implement A/B testing and progressive exposure deployment Completed on 11/19/2023 Badge Manage alerts, blameless retrospectives and a just culture Completed on 11/19/2023 Badge Design processes to automate application analytics Completed on 11/19/2023 Badge Share knowledge within teams Completed on 11/19/2023 Badge Develop monitor and status dashboards Completed on 11/19/2023 Badge Implement tools to track usage and flow Completed on 11/19/2023 Badge Manage Git repositories Completed on 11/19/2023 Badge Plan foster inner source Completed on 11/19/2023 Badge Explore Git hooks Completed on 11/19/2023 Badge Identify technical debt Completed on 11/19/2023 Badge Collaborate with pull requests in Azure Repos Completed on 11/19/2023 Badge Manage Git branches and workflows Completed on 11/19/2023 Badge Structure your Git Repo Completed on 11/19/2023 Badge Introduction to data protection and privacy Completed on 11/19/2023 Badge Discover the potential of Azure for government Completed on 11/19/2023 Badge Support data classification with private and hybrid clouds Completed on 11/19/2023 Badge Safeguard public sector data with Azure Completed on 11/19/2023 Badge Describe the identity protection and governance capabilities of Microsoft Entra Completed on 11/19/2023 Badge Describe access management capabilities of Microsoft Entra ID Completed on 11/19/2023 Badge Describe the authentication capabilities of Microsoft Entra ID Completed on 11/19/2023 Badge Describe the function and identity types of Microsoft Entra ID Completed on 11/19/2023 Badge Describe identity concepts Completed on 11/19/2023 Badge Describe security and compliance concepts Completed on 11/19/2023 Badge Describe analytics capabilities of Microsoft 365 Completed on 11/19/2023 Badge Describe endpoint modernization, management concepts, and deployment options in Microsoft 365 Completed on 11/19/2023 Badge Describe collaboration solutions of Microsoft 365 Completed on 11/19/2023 Badge Describe productivity solutions of Microsoft 365 Completed on 11/19/2023 Badge What is Microsoft 365? Completed on 11/19/2023 Badge Use Azure AI Services for Language in a Microsoft Copilot Studio bot Completed on 11/19/2023 Badge Set up a Microsoft Copilot Studio bot for voice Completed on 11/19/2023 Badge Manage Power Virtual Agents Completed on 11/19/2023 Badge Build effective bots with Microsoft Copilot Studio Completed on 11/19/2023 Badge Enhance Microsoft Copilot Studio bots Completed on 11/19/2023 Badge Work with entities and variables in Microsoft Copilot Studio Completed on 11/19/2023 Badge Manage topics in Microsoft Copilot Studio Completed on 11/19/2023 Badge Get started with Microsoft Copilot Studio bots Completed on 11/19/2023 Badge Create calculation groups Completed on 11/19/2023 Badge Use DAX time intelligence functions in Power BI Desktop models Completed on 11/19/2023 Badge Create Power BI model relationships Completed on 11/19/2023 Badge Use tools to optimize Power BI performance Completed on 11/19/2023 Badge Enforce Power BI model security Completed on 11/19/2023 Badge Publish and share in Power BI Completed on 11/19/2023 Badge Explore data in Power BI Completed on 11/19/2023 Badge Use visuals in Power BI Completed on 11/19/2023 Badge Model data in Power BI Completed on 11/19/2023 Badge Get started building with Power BI Completed on 11/19/2023 Badge Discover data analysis Completed on 11/19/2023 Badge Operate a guide in Dynamics 365 Guides Completed on 11/19/2023 Badge Author a guide in Dynamics 365 Guides Completed on 11/19/2023 Badge Dynamics 365 Guides for administrators Completed on 11/19/2023 Badge Get started with Dynamics 365 Guides Completed on 11/19/2023 Badge Embed 21st century skills with 21st century learning design Completed on 11/19/2023 Badge Deepen educational experiences with the 21CLD ICT for learning dimension Completed on 11/19/2023 Badge Develop learner executive function with the 21CLD self-regulation dimension Completed on 11/19/2023 Badge Improve communication skills with the 21CLD skilled communication dimension Completed on 11/19/2023 Badge Innovate learning with the 21CLD real-world problem solving and innovation dimension Completed on 11/19/2023 Badge Practice collaborative skills with the 21CLD collaboration dimension Completed on 11/19/2023 Badge Develop critical thinking skills with the 21CLD knowledge construction dimension Completed on 11/19/2023 Badge Transform learning with 21st century learning Completed on 11/19/2023 Badge Set up number series and trail codes in Dynamics 365 Business Central Completed on 11/18/2023 Badge Set up general ledger configuration options in Dynamics 365 Business Central Completed on 11/18/2023 Badge Set up inventory replenishment in Dynamics 365 Business Central Completed on 11/18/2023 Badge Plan items in Dynamics 365 Business Central Completed on 11/18/2023 Badge Set up inventory planning in Dynamics 365 Business Central Completed on 11/18/2023 Badge Demand Driven Material Requirements Planning in Dynamics 365 Supply Chain Management Completed on 11/18/2023 Badge Use master planning in Dynamics 365 Supply Chain Management Completed on 11/18/2023 Badge Set up Master Planning in Dynamics 365 Supply Chain Management Completed on 11/18/2023 Badge Create bill of materials in Dynamics 365 Supply Chain Management Completed on 11/18/2023 Badge Create products and product masters in Dynamics 365 Supply Chain Management Completed on 11/18/2023 Badge Use inventory reports in Dynamics 365 Supply Chain Management Completed on 11/18/2023 Badge Configure and work with inventory management in Dynamics 365 Supply Chain Management Completed on 11/18/2023 Badge Get started with Dynamics 365 Supply Chain Management Completed on 11/18/2023 Badge Introduction to scripting in PowerShell Completed on 11/18/2023 Badge Write your first PowerShell code Completed on 11/18/2023 Badge Connect commands into a pipeline Completed on 11/18/2023 Badge Discover commands in PowerShell Completed on 11/18/2023 Badge Introduction to PowerShell Completed on 11/18/2023 Badge Write your first program in C++ Completed on 11/18/2023 Badge Create a Bot with the Bot Framework Composer Completed on 11/17/2023 Badge Create a bot with the Bot Framework SDK Completed on 11/17/2023 Badge Deploy Azure AI services in containers Completed on 11/17/2023 Badge Monitor Azure AI services Completed on 11/17/2023 Badge Secure Azure AI services Completed on 11/17/2023 Badge Create and consume Azure AI services Completed on 11/17/2023 Badge Prepare to develop AI solutions on Azure Completed on 11/17/2023 Badge Understand the MySQL storage engine Completed on 11/17/2023 Badge Understand client-server communication in MySQL Completed on 11/17/2023 Badge Explore MySQL Architecture Completed on 11/17/2023 Badge Understand concurrency in MySQL Completed on 11/17/2023 Badge Secure MySQL Completed on 11/17/2023 Badge Beneath the surface: Device details for IT administrators Completed on 11/17/2023 Badge Analyze DevOps Continuous Planning and Continuous Integration Completed on 11/15/2023 Badge Route system feedback to development teams Completed on 11/15/2023 Badge Explain DevOps Continuous Delivery and Continuous Quality Completed on 11/15/2023 Badge Characterize DevOps Continuous Collaboration and Continuous Improvement Completed on 11/15/2023 Badge Introduce the foundation pillars of DevOps: Culture and Lean Product Completed on 11/15/2023 Badge Assess your existing software development process Completed on 11/15/2023 Badge Manage Agile software delivery plans across teams Completed on 11/15/2023 Badge Choose an Agile approach to software development Completed on 11/15/2023 Badge Introduction to Azure DevOps Completed on 11/15/2023 Badge Introduction to Git Completed on 11/15/2023 Badge Edit code through branching and merging in Git Completed on 11/15/2023 Badge Collaborate with Git Completed on 11/15/2023 Badge How to create and modify a Git project Completed on 11/15/2023 Badge Enhance creativity to advance learning with Windows 11 and Microsoft 365 tools Completed on 11/14/2023 Badge Increase productivity with Office, OneNote, and Edge browser in Windows 11 Completed on 11/14/2023 Badge Build community with Teams and OneNote Completed on 11/14/2023 Badge Transition to and prepare for fundamentals-level security, compliance, and identity course Completed on 11/14/2023 Badge Develop search strategies with Search Coach and Search Progress Completed on 11/14/2023 Badge Perform hyperparameter tuning with Azure Machine Learning Completed on 11/14/2023 Badge Track model training with MLflow in jobs Completed on 11/14/2023 Badge Run a training script as a command job in Azure Machine Learning Completed on 11/14/2023 Badge Deploy a model to a batch endpoint Completed on 11/14/2023 Badge Deploy a model to a managed online endpoint Completed on 11/14/2023 Badge Run pipelines in Azure Machine Learning Completed on 11/14/2023 Badge Find the best classification model with Automated Machine Learning Completed on 11/14/2023 Badge Make data available in Azure Machine Learning Completed on 11/14/2023 Badge Build a machine learning model Completed on 11/14/2023 Badge Data collection and manipulation Completed on 11/14/2023 Badge Introduction to rocket launches Completed on 11/14/2023 Badge Digital citizenship: Prepare today's learners for online success Completed on 11/14/2023 Badge Extract invoice data with AI Builder's prebuilt model Completed on 11/14/2023 Badge Automate the processing of documents with the AI Builder prepackaged solution Completed on 11/14/2023 Badge Manage models in AI Builder Completed on 11/14/2023 Badge Get started with AI Builder Completed on 11/14/2023 Badge Use text generation in AI Builder Completed on 11/14/2023 Badge Introduction to expressions in Power Automate Completed on 11/14/2023 Badge Upload, download, and manage data with Azure Storage Explorer Completed on 11/13/2023 Badge Control access to Azure Storage with shared access signatures Completed on 11/13/2023 Badge Configure Azure Storage with tools Completed on 11/13/2023 Badge Configure Azure Files and Azure File Sync Completed on 11/13/2023 Badge Configure Azure Storage security Completed on 11/13/2023 Badge Find commands and Get-Help in Windows PowerShell Completed on 11/13/2023 Badge Understand the command syntax in Windows PowerShell Completed on 11/13/2023 Badge Review Windows PowerShell Completed on 11/13/2023 Badge Manage mail flow rules Completed on 11/13/2023 Badge Troubleshoot mail flow Completed on 11/13/2023 Badge Manage mail flow Completed on 11/13/2023 Badge Troubleshoot audio, video, and client issues Completed on 11/13/2023 Badge Configure auto attendants and call queues Completed on 11/13/2023 Badge Configure and manage voice users Completed on 11/13/2023 Badge Configure and deploy Teams Phone Completed on 11/13/2023 Badge Plan for Teams Phone Completed on 11/13/2023 Badge Configure, deploy, and manage Teams devices Completed on 11/13/2023 Badge Plan for Microsoft Teams Rooms and Surface Hub Completed on 11/13/2023 Badge Manage meetings and events experiences Completed on 11/13/2023 Badge Introduction to Teams meetings and calling Completed on 11/13/2023 Badge Monitor your Microsoft Teams environment Completed on 11/13/2023 Badge Implement lifecycle management and governance for Microsoft Teams Completed on 11/13/2023 Badge Plan and deploy Microsoft Teams Completed on 11/13/2023 Badge Explore Microsoft Teams Completed on 11/13/2023 Badge Examine Azure Identity Protection Completed on 11/13/2023 Badge Examine Privileged Identity Management Completed on 11/13/2023 Badge Examine Microsoft Secure Score Completed on 11/13/2023 Badge Explore security solutions in Microsoft 365 Defender Completed on 11/13/2023 Badge Explore the Zero Trust security model Completed on 11/13/2023 Badge Examine threat vectors and data breaches Completed on 11/13/2023 Badge Use OneDrive in Microsoft 365 Completed on 11/13/2023 Badge Configure client connectivity to Microsoft 365 Completed on 11/13/2023 Badge Add a custom domain in Microsoft 365 Completed on 11/13/2023 Badge Manage groups in Microsoft 365 Completed on 11/13/2023 Badge Manage users, licenses, and mail contacts in Microsoft 365 Completed on 11/13/2023 Badge Configure your Microsoft 365 experience Completed on 11/13/2023 Badge Implement compliance for Microsoft Teams Completed on 11/13/2023 Badge Implement security for Microsoft Teams Completed on 11/13/2023 Badge Manage access for external users Completed on 11/13/2023 Badge Plan and configure network settings for Microsoft Teams Completed on 11/13/2023 Badge Support social and emotional learning with Microsoft tools Completed on 11/12/2023 Badge Keep students engaged: Build strong student/teacher connections in a remote learning environment Completed on 11/12/2023 Badge Stay connected with remote learning through Microsoft Teams and Office 365 Completed on 11/12/2023 Badge Hybrid learning in the primary classroom Completed on 11/12/2023 Badge Hybrid learning: A new model for the future of learning Completed on 11/12/2023 Badge Hybrid learning for the adolescent learner Completed on 11/12/2023 Badge Hybrid learning in the intermediate classroom Completed on 11/12/2023 Badge Accessibility, special education, and online learning: Supporting equity in a remote learning environment Completed on 11/12/2023 Badge Differentiation in the classroom using the built-in tools in Office 365 and Windows Completed on 11/12/2023 Badge Simplify cloud procurement and governance with Azure Marketplace Completed on 11/12/2023 Badge Design a program launch strategy Completed on 11/12/2023 Badge Prepare for a program approval event Completed on 11/12/2023 Badge Design degree program curricula that implement certification Completed on 11/12/2023 Badge Define academic and industry requirements for implementing certifications in degree programs Completed on 11/12/2023 Badge Work with data source limits (delegation limits) in a Power Apps canvas app Completed on 11/11/2023 Badge Work with relational data in a Power Apps canvas app Completed on 11/11/2023 Badge Use custom connectors in a Power Apps canvas app Completed on 11/11/2023 Badge Connect to other data in a Power Apps canvas app Completed on 11/11/2023 Badge Use and understand Controls in a canvas app in Power Apps Completed on 11/11/2023 Badge Document and test your Power Apps application Completed on 11/11/2023 Badge Build a mobile-optimized app from Power Apps Completed on 11/11/2023 Badge Manage apps in Power Apps Completed on 11/11/2023 Badge Navigation in a canvas app in Power Apps Completed on 11/11/2023 Badge How to build the UI in a canvas app in Power Apps Completed on 11/11/2023 Badge Customize a canvas app in Power Apps Completed on 11/11/2023 Badge Get started with Power Apps canvas apps Completed on 11/11/2023 Badge How to build your first model-driven app with Dataverse Completed on 11/11/2023 Badge Configure forms, charts, and dashboards in model-driven apps Completed on 11/11/2023 Badge Get started with model-driven apps in Power Apps Completed on 11/11/2023 Badge Create tables in Dataverse Completed on 11/11/2023 Badge Validation of Teams apps extensible across Microsoft 365 Completed on 11/10/2023 Badge Add significant value to your Teams app Completed on 11/10/2023 Badge Publish Teams apps in Microsoft Teams store Completed on 11/10/2023 Badge Azure Health Bot built-in scenarios Completed on 11/10/2023 Badge Language understanding in Azure Health Bot Completed on 11/10/2023 Badge Azure Health Bot case studies Completed on 11/10/2023 Badge Basic Azure Health Bot Completed on 11/10/2023 Badge Introduction to Azure Health Bot Completed on 11/10/2023 Badge Channelized Azure Health Bot Completed on 11/10/2023 Badge Integrate Azure Health Bot with a database Completed on 11/10/2023 Badge Enhanced Azure Health Bot Completed on 11/10/2023 Badge Azure Health Bot scenario templates Completed on 11/10/2023 Badge Deploy a customer service bot Completed on 11/10/2023 Badge Create a chatbot to help students learn geography Completed on 11/10/2023 Badge Introduction to responsible bots Completed on 11/10/2023 Badge Detect objects in images with Azure AI Custom Vision Completed on 11/10/2023 Badge Translate text and speech with Azure AI services Completed on 11/10/2023 Badge Classify images with Azure AI Custom Vision Completed on 11/10/2023 Badge Challenge project - Add image analysis and generation capabilities to your application Completed on 11/10/2023 Badge Challenge project - Work with variable data in C# Completed on 11/10/2023 Badge Guided project - Work with variable data in C# Completed on 11/10/2023 Badge Modify the content of strings using built-in string data type methods in C# Completed on 11/10/2023 Badge Format alphanumeric data for presentation in C# Completed on 11/10/2023 Badge Perform operations on arrays using helper methods in C# Completed on 11/10/2023 Badge Convert data types using casting and conversion techniques in C# Completed on 11/10/2023 Badge Choose the correct data type in your C# code Completed on 11/10/2023 Badge Challenge project - Create a mini-game Completed on 11/10/2023 Badge Guided project - Plan a Petting Zoo Visit Completed on 11/10/2023 Badge Create C# methods that return values Completed on 11/10/2023 Badge Create C# methods with parameters Completed on 11/10/2023 Badge Write your first C# method Completed on 11/10/2023 Badge Challenge project - Debug a C# console application using Visual Studio Code Completed on 11/10/2023 Badge Guided project - Debug and handle exceptions in a C# console application using Visual Studio Code Completed on 11/10/2023 Badge Create and throw exceptions in C# console applications Completed on 11/10/2023 Badge Implement exception handling in C# console applications Completed on 11/10/2023 Badge Implement the Visual Studio Code debugging tools for C# Completed on 11/10/2023 Badge Review the principles of code debugging and exception handling Completed on 11/10/2023 Badge Evaluate Boolean expressions to make decisions in C# Completed on 11/10/2023 Badge Challenge project - Develop branching and looping structures in C# Completed on 11/10/2023 Badge Guided project - Develop conditional branching and looping structures in C# Completed on 11/10/2023 Badge Add looping logic to your code using the do-while and while statements in C# Completed on 11/10/2023 Badge Iterate through a code block using for statement in C# Completed on 11/10/2023 Badge Control variable scope and logic using code blocks in C# Completed on 11/10/2023 Badge Branch the flow of code using the switch-case construct in C# Completed on 11/10/2023 Badge Get started with Jupyter notebooks for Python Completed on 11/9/2023 Badge Python error handling Completed on 11/9/2023 Badge Python functions Completed on 11/9/2023 Badge Manage data with Python dictionaries Completed on 11/9/2023 Badge Use 'while' and 'for' loops in Python Completed on 11/9/2023 Badge Introduction to lists in Python Completed on 11/9/2023 Badge Use mathematical operations in Python Completed on 11/9/2023 Badge Use strings in Python Completed on 11/9/2023 Badge Use Boolean logic in Python Completed on 11/9/2023 Badge Create and manage projects in Python Completed on 11/9/2023 Badge Write your first Python programs Completed on 11/9/2023 Badge Get started with Python in Visual Studio Code Completed on 11/9/2023 Badge Using GitHub Copilot with Python Completed on 11/9/2023 Badge Using GitHub Copilot with JavaScript Completed on 11/9/2023 Badge Introduction to GitHub Copilot for Business Completed on 11/9/2023 Badge Introduction to GitHub Copilot Completed on 11/9/2023 Badge Deploy a model with GitHub Actions Completed on 11/9/2023 Badge Work with environments in GitHub Actions Completed on 11/9/2023 Badge Work with linting and unit testing in GitHub Actions Completed on 11/9/2023 Badge Trigger GitHub Actions with feature-based development Completed on 11/9/2023 Badge Trigger Azure Machine Learning jobs with GitHub Actions Completed on 11/9/2023 Badge Use an Azure Machine Learning job for automation Completed on 11/9/2023 Badge Train and evaluate regression models Completed on 11/9/2023 Badge Explore and analyze data with Python Completed on 11/9/2023 Badge Train and evaluate deep learning models Completed on 11/9/2023 Badge Train and evaluate clustering models Completed on 11/9/2023 Badge Train and evaluate classification models Completed on 11/9/2023 Badge Measure and optimize model performance with ROC and AUC Completed on 11/9/2023 Badge Confusion matrix and data imbalances Completed on 11/9/2023 Badge Select and customize architectures and hyperparameters using random forest Completed on 11/9/2023 Badge Create and understand classification models in machine learning Completed on 11/9/2023 Badge Refine and test machine learning models Completed on 11/9/2023 Badge Train and understand regression models in machine learning Completed on 11/9/2023 Badge Introduction to data for machine learning Completed on 11/9/2023 Badge Build classical machine learning models with supervised learning Completed on 11/9/2023 Badge Introduction to machine learning Completed on 11/9/2023 Badge Create a clustering model with Azure Machine Learning designer Completed on 11/9/2023 Badge Create a classification model with Azure Machine Learning designer Completed on 11/9/2023 Badge Create a regression model with Azure Machine Learning designer Completed on 11/9/2023 Badge Use Automated Machine Learning in Azure Machine Learning Completed on 11/9/2023 Badge Explore developer tools for workspace interaction Completed on 11/9/2023 Badge Explore Azure Machine Learning workspace resources and assets Completed on 11/9/2023 Badge Explore Azure Storage for non-relational data Completed on 11/8/2023 Badge Explore fundamentals of Azure Cosmos DB Completed on 11/8/2023 Badge Explore relational database services in Azure Completed on 11/8/2023 Badge Explore fundamental relational data concepts Completed on 11/8/2023 Badge Fundamentals of Azure AI services Completed on 11/8/2023 Badge Fundamentals of machine learning Completed on 11/8/2023 Badge Fundamental AI Concepts Completed on 11/8/2023 Badge Fundamentals of Knowledge Mining with Azure Cognitive Search Completed on 11/8/2023 Badge Fundamentals of Azure AI Document Intelligence Completed on 11/8/2023 Badge Introduction to Computer Vision with PyTorch Completed on 11/8/2023 Badge Introduction to PyTorch Completed on 11/8/2023 Badge Introduction to audio classification with PyTorch Completed on 11/8/2023 Badge Introduction to Natural Language Processing with PyTorch Completed on 11/8/2023 Badge Transcribe large amounts of audio data with Batch Transcription Completed on 11/8/2023 Badge Fundamentals of optical character recognition Completed on 11/8/2023 Badge Fundamentals of Facial Recognition Completed on 11/8/2023 Badge Fundamentals of Computer Vision Completed on 11/8/2023 Badge Introduction to Azure Bot Service and Bot Framework Composer Completed on 11/8/2023 Badge Fundamentals of question answering with the Language Service Completed on 11/8/2023 Badge Fundamentals of Text Analysis with the Language Service Completed on 11/8/2023 Badge Fundamentals of Azure AI Speech Completed on 11/8/2023 Badge Fundamentals of conversational language understanding Completed on 11/8/2023 Badge Use your own data with Azure OpenAI Service Completed on 11/8/2023 Badge Generate images with Azure OpenAI Service Completed on 11/8/2023 Badge Generate code with Azure OpenAI Service Completed on 11/8/2023 Badge Apply prompt engineering with Azure OpenAI Service Completed on 11/8/2023 Badge Build natural language solutions with Azure OpenAI Service Completed on 11/8/2023 Badge Get started with Azure OpenAI Service Completed on 11/8/2023 Badge Fundamentals of Responsible Generative AI Completed on 11/8/2023 Badge Fundamentals of Azure OpenAI Service Completed on 11/8/2023 Badge Fundamentals of Generative AI Completed on 11/8/2023 Badge Describe monitoring tools in Azure Completed on 11/8/2023 Badge Describe features and tools for managing and deploying Azure resources Completed on 11/8/2023 Badge Describe features and tools in Azure for governance and compliance Completed on 11/8/2023 Badge Describe cost management in Azure Completed on 11/8/2023 Badge Align requirements with cloud types and service models in Azure Completed on 11/8/2023 Badge Move Azure resources to another resource group Completed on 11/8/2023 Badge Control and organize Azure resources with Azure Resource Manager Completed on 11/8/2023 Badge Create custom roles for Azure resources with role-based access control (RBAC) Completed on 11/8/2023 Badge Manage access to an Azure subscription by using Azure role-based access control (Azure RBAC) Completed on 11/8/2023 Badge Secure your Azure resources with Azure role-based access control (Azure RBAC) Completed on 11/8/2023 Badge Create Azure users and groups in Microsoft Entra ID Completed on 11/8/2023 Badge Configure role-based access control Completed on 11/8/2023 Badge Configure Azure Policy Completed on 11/8/2023 Badge Configure subscriptions Completed on 11/8/2023 Badge Configure user and group accounts Completed on 11/8/2023 Badge Configure Microsoft Entra ID Completed on 11/8/2023 Badge Allow users to reset their password with Microsoft Entra self-service password reset Completed on 11/8/2023 Badge Manage device identity with Microsoft Entra join and Enterprise State Roaming Completed on 11/8/2023 Badge Secure Microsoft Entra users with multifactor authentication Completed on 11/8/2023 Badge Implement and manage hybrid identity Completed on 11/8/2023 Badge Implement and manage external identities Completed on 11/8/2023 Badge Create, configure, and manage identities Completed on 11/8/2023 Badge Implement initial configuration of Microsoft Entra ID Completed on 11/8/2023 Badge Investigate threats by using audit features in Microsoft 365 Defender and Microsoft Purview Standard Completed on 11/8/2023 Badge Manage insider risk in Microsoft Purview Completed on 11/8/2023 Badge Respond to data loss prevention alerts using Microsoft 365 Completed on 11/8/2023 Badge Utilize Vulnerability Management in Microsoft Defender for Endpoint Completed on 11/8/2023 Badge Configure for alerts and detections in Microsoft Defender for Endpoint Completed on 11/8/2023 Badge Configure and manage automation using Microsoft Defender for Endpoint Completed on 11/8/2023 Badge Perform evidence and entities investigations using Microsoft Defender for Endpoint Completed on 11/8/2023 Badge Perform actions on a device using Microsoft Defender for Endpoint Completed on 11/8/2023 Badge Perform device investigations in Microsoft Defender for Endpoint Completed on 11/8/2023 Badge Implement Windows security enhancements with Microsoft Defender for Endpoint Completed on 11/8/2023 Badge Deploy the Microsoft Defender for Endpoint environment Completed on 11/8/2023 Badge Protect against threats with Microsoft Defender for Endpoint Completed on 11/8/2023 Badge Challenge project - Develop foreach and if-elseif-else structures to process array data in C# Completed on 11/8/2023 Badge Guided project - Develop foreach and if-elseif-else structures to process array data in C# Completed on 11/8/2023 Badge Create readable code with conventions, whitespace, and comments in C# Completed on 11/8/2023 Badge Store and iterate through sequences of data using Arrays and the foreach statement in C# Completed on 11/8/2023 Badge Add decision logic to your code using `if`, `else`, and `else if` statements in C# Completed on 11/8/2023 Badge Call methods from the .NET Class Library using C# Completed on 11/8/2023 Badge Install and configure Visual Studio Code Completed on 11/8/2023 Badge Perform basic string formatting in C# Completed on 11/8/2023 Badge Store and retrieve data using literal and variable values in C# Completed on 11/8/2023 Badge Write your first C# code Completed on 11/8/2023 Badge Guided project - Calculate final GPA Completed on 11/8/2023 Badge Guided project - Calculate and print student grades Completed on 11/8/2023 Badge Perform basic operations on numbers in C# Completed on 11/8/2023 Badge Explore Windows Editions Completed on 11/8/2023 Badge Explore the Enterprise Desktop Completed on 11/8/2023 Badge Examine data security and compliance in Microsoft 365 Copilot Completed on 11/8/2023 Badge Implement Microsoft 365 Copilot Completed on 11/8/2023 Badge Examine the Microsoft 365 Copilot design Completed on 11/8/2023 Badge Manage records in Microsoft Purview Completed on 11/8/2023 Badge Manage data retention in Microsoft 365 workloads Completed on 11/8/2023 Badge Manage the data lifecycle in Microsoft Purview Completed on 11/8/2023 Badge Configure DLP policies for Microsoft Defender for Cloud Apps and Power Platform Completed on 11/8/2023 Badge Prevent data loss in Microsoft Purview Completed on 11/8/2023 Badge Manage data loss prevention policies and reports in Microsoft 365 Completed on 11/8/2023 Badge Apply and manage sensitivity labels Completed on 11/8/2023 Badge Protect information in Microsoft Purview Completed on 11/8/2023 Badge Deploy Microsoft Purview Message Encryption Completed on 11/8/2023 Badge Understand Microsoft 365 encryption Completed on 11/8/2023 Badge Create and manage sensitive information types Completed on 11/8/2023 Badge Classify data for protection and governance Completed on 11/8/2023 Badge Introduction to information protection and data lifecycle management in Microsoft Purview Completed on 11/8/2023 Badge Design an application architecture Completed on 11/8/2023 Badge Design an Azure compute solution Completed on 11/8/2023 Badge Design migrations Completed on 11/8/2023 Badge Design network solutions Completed on 11/8/2023 Badge Design a solution to log and monitor Azure resources Completed on 11/8/2023 Badge Design authentication and authorization solutions Completed on 11/8/2023 Badge Design governance Completed on 11/8/2023 Badge Save money with Azure Reserved Instances Completed on 11/8/2023 Badge Introduction to analyzing costs and creating budgets with Microsoft Cost Management Completed on 11/8/2023 Badge Microsoft Azure Well-Architected Framework - Cost optimization Completed on 11/8/2023 Badge Introduction to the Microsoft Azure Well-Architected Framework Completed on 11/8/2023 Badge Microsoft Cloud Adoption Framework for Azure Completed on 11/8/2023 Badge Describe Azure identity, access, and security Completed on 11/8/2023 Badge Describe Azure storage services Completed on 11/8/2023 Badge Describe Azure compute and networking services Completed on 11/8/2023 Badge Describe the core architectural components of Azure Completed on 11/8/2023 Badge Describe cloud service types Completed on 11/8/2023 Badge Describe the benefits of using cloud services Completed on 11/8/2023 Badge Describe cloud computing Completed on 11/8/2023 Badge Publish an API to Azure Static Web Apps Completed on 11/8/2023 Badge Publish an Angular, React, Svelte, or Vue JavaScript app with Azure Static Web Apps Completed on 11/8/2023 Badge Create and publish a static web app with Gatsby and Azure Static Web Apps Completed on 11/8/2023 Badge Publish a Blazor WebAssembly app and .NET API with Azure Static Web Apps Completed on 11/8/2023 Badge Authenticate users with Azure Static Web Apps Completed on 11/8/2023 Badge Sign in users with Microsoft Entra ID in a Java web app Completed on 11/8/2023 Badge Accelerate a Spring Boot application with Azure Cache for Redis Completed on 11/8/2023 Badge Enable asynchronous messaging in Java apps by using JMS and Azure Service Bus Completed on 11/8/2023 Badge Build a Java app with cloud-scale NoSQL Cosmos DB Completed on 11/8/2023 Badge Deploy a Java EE (Jakarta EE) application to Azure Completed on 11/8/2023 Badge Deploy Spring microservices to Azure Completed on 11/8/2023 Badge Store application data with Azure Blob Storage Completed on 11/8/2023 Badge Secure your Azure Storage account Completed on 11/8/2023 Badge Connect an app to Azure Storage Completed on 11/8/2023 Badge Create an Azure Storage account Completed on 11/8/2023 Badge Choose a data storage approach in Azure Completed on 11/8/2023 Badge Introduction to Docker containers Completed on 11/8/2023 Badge Secure your identities by using Microsoft Entra ID Completed on 11/8/2023 Badge Automate Azure tasks using scripts with PowerShell Completed on 11/8/2023 Badge Control Azure services with the CLI Completed on 11/8/2023 Badge Fundamentals of network security Completed on 11/8/2023 Badge Fundamentals of computer networking Completed on 11/8/2023 Badge Introduction to Azure virtual machines Completed on 11/8/2023 Badge Create a Windows virtual machine in Azure Completed on 11/8/2023 Badge Provisioning a Linux virtual machine in Microsoft Azure Completed on 11/8/2023 Badge Plan your Linux environment in Azure Completed on 11/8/2023 Badge Introduction to Linux on Azure Completed on 11/8/2023 Badge Build and run a web application with the MEAN stack on an Azure Linux virtual machine Completed on 11/8/2023 Badge Optimizing IT operations and management with Azure Automanage Completed on 11/8/2023 Badge Manage hybrid workloads with Azure Arc Completed on 11/8/2023 Badge Administer and manage Windows Server IaaS Virtual Machine remotely Completed on 11/8/2023 Badge Perform Windows Server secure administration Completed on 11/8/2023 Badge Perform post-installation configuration of Windows Server Completed on 11/8/2023 Badge Describe Windows Server administration tools Completed on 11/8/2023 Badge Implement and manage Active Directory Certificate Services Completed on 11/8/2023 Badge Manage advanced features of AD DS Completed on 11/8/2023 Badge Implement Group Policy Objects Completed on 11/8/2023 Badge Manage AD DS domain controllers and FSMO roles Completed on 11/8/2023 Badge Introduction to AD DS Completed on 11/8/2023 Badge Deploy and manage Azure IaaS Active Directory domain controllers in Azure Completed on 11/8/2023 Badge Implement hybrid identity with Windows Server Completed on 11/8/2023 Badge Implement hybrid network infrastructure Completed on 11/8/2023 Badge Implement remote access Completed on 11/8/2023 Badge Implement IP Address Management Completed on 11/8/2023 Badge Implement Windows Server DNS Completed on 11/8/2023 Badge Deploy and manage DHCP Completed on 11/8/2023 Badge Implement DNS for Windows Server IaaS VMs Completed on 11/8/2023 Badge Implement Windows Server IaaS VM IP addressing and routing Completed on 11/8/2023 Badge Implement Windows Server IaaS VM network security Completed on 11/8/2023 Badge Windows Server update management Completed on 11/8/2023 Badge Hardening Windows Server Completed on 11/8/2023 Badge Secure Windows Server user accounts Completed on 11/8/2023 Badge Secure Windows Server DNS Completed on 11/8/2023 Badge Implement change tracking and file integrity monitoring for Windows IaaS VMs Completed on 11/8/2023 Badge Configure BitLocker disk encryption for Windows IaaS Virtual Machines Completed on 11/8/2023 Badge Create and implement application allowlists with adaptive application control Completed on 11/8/2023 Badge Manage Azure updates Completed on 11/8/2023 Badge Audit the security of Windows Server IaaS Virtual Machines Completed on 11/8/2023 Badge Configure and monitor Microsoft Sentinel Completed on 11/8/2023 Badge Enable and manage Microsoft Defender for Cloud Completed on 11/8/2023 Badge Configure and manage Azure Monitor Completed on 11/8/2023 Badge Improve your cloud security posture with Microsoft Defender for Cloud Completed on 11/8/2023 Badge Secure your cloud apps and services with Microsoft Defender for Cloud Apps Completed on 11/8/2023 Badge Safeguard your environment with Microsoft Defender for Identity Completed on 11/8/2023 Badge Remediate risks with Microsoft Defender for Office 365 Completed on 11/8/2023 Badge Protect your identities with Microsoft Entra ID Protection Completed on 11/8/2023 Badge Mitigate incidents using Microsoft 365 Defender Completed on 11/8/2023 Badge Introduction to Microsoft 365 threat protection Completed on 11/8/2023 Badge Configure Azure Load Balancer Completed on 11/7/2023 Badge Configure network routing and endpoints Completed on 11/7/2023 Badge Configure Azure Virtual Network peering Completed on 11/7/2023 Badge Configure Azure DNS Completed on 11/7/2023 Badge Configure network security groups Completed on 11/7/2023 Badge Configure virtual networks Completed on 11/7/2023 Badge Improve application scalability and resiliency by using Azure Load Balancer Completed on 11/7/2023 Badge Manage and control traffic flow in your Azure deployment with routes Completed on 11/7/2023 Badge Host your domain on Azure DNS Completed on 11/7/2023 Badge Distribute your services across Azure virtual networks and integrate them by using virtual network peering Completed on 11/7/2023 Badge Design an IP addressing schema for your Azure deployment Completed on 11/7/2023 Badge Configure Azure Application Gateway Completed on 11/7/2023 Badge Design an enterprise governance strategy Completed on 11/7/2023 Badge Configure Microsoft Entra Privileged Identity Management Completed on 11/7/2023 Badge Deploy Microsoft Entra ID Protection Completed on 11/7/2023 Badge Implement Hybrid identity Completed on 11/7/2023 Badge Secure Azure solutions with Microsoft Entra ID Completed on 11/7/2023 Badge Functional Consultant skills Completed on 11/7/2023 Badge Use knowledge articles to resolve Dynamics 365 Customer Service cases Completed on 11/7/2023 Badge Search and filter knowledge articles by using Dynamics 365 Customer Service Completed on 11/7/2023 Badge Create knowledge management solutions in Dynamics 365 Customer Service Completed on 11/7/2023 Badge Translate Dynamics 365 apps and documentation with Dynamics 365 Translation Service Completed on 11/7/2023 Badge Challenge project - Architecting solutions for a new product line for customers Completed on 11/7/2023 Badge Perform fit gap analysis Completed on 11/7/2023 Badge Work with requirements for Microsoft Power Platform and Dynamics 365 Completed on 11/7/2023 Badge Propose a solution as a Solution Architect for Microsoft Power Platform and Dynamics 365 Completed on 11/7/2023 Badge Discover customer needs as a Solution Architect for Dynamics 365 and Microsoft Power Platform Completed on 11/7/2023 Badge Becoming a solution architect for Dynamics 365 and Microsoft Power Platform Completed on 11/7/2023 Badge Integration design for Dynamics 365 solutions Completed on 11/7/2023 Badge Review the security model for your Dynamics 365 solutions Completed on 11/7/2023 Badge Create a data migration strategy for Dynamics 365 solutions Completed on 11/7/2023 Badge Gap solution design for Dynamics 365 solutions Completed on 11/7/2023 Badge Business intelligence and analytics design for Dynamics 365 solutions Completed on 11/7/2023 Badge Design data models for Dynamics 365 solutions Completed on 11/7/2023 Badge Plan a testing strategy for your Dynamics 365 solution Completed on 11/7/2023 Badge Create a solution blueprint for Dynamics 365 solutions Completed on 11/7/2023 Badge Get started with Success by Design for Dynamics 365 Completed on 11/7/2023 Badge Post go-live strategy for Dynamics 365 solutions Completed on 11/7/2023 Badge Cutover strategy for Dynamics 365 solutions Completed on 11/7/2023 Badge Implement a performance strategy for Dynamics 365 solutions Completed on 11/7/2023 Badge Dual-write implementation for Dynamics 365 solutions Completed on 11/7/2023 Badge Implement common integration features in finance and operations apps Completed on 11/7/2023 Badge Personalize finance and operations apps Completed on 11/7/2023 Badge Work with workflows in finance and operations apps Completed on 11/7/2023 Badge Set up batch jobs in finance and operations apps Completed on 11/7/2023 Badge Plan and implement legal entities in finance and operations apps Completed on 11/7/2023 Badge Plan and configure the global address book in finance and operations apps Completed on 11/7/2023 Badge Feature management in finance and operations apps Completed on 11/7/2023 Badge Prepare to go-live with finance and operations apps Completed on 11/7/2023 Badge Implement role-based security in finance and operations apps Completed on 11/7/2023 Badge Plan and implement security in finance and operations apps Completed on 11/7/2023 Badge Work with performance and monitoring tools in finance and operations apps Completed on 11/7/2023 Badge Updates and upgrades for finance and operations apps Completed on 11/7/2023 Badge Design and build mobile apps for finance and operations apps Completed on 11/7/2023 Badge Describe building automation with Microsoft Power Automate Completed on 11/7/2023 Badge Identify foundational components of Microsoft Power Platform Completed on 11/7/2023 Badge Describe how to build applications with Microsoft Power Apps Completed on 11/7/2023 Badge Describe the business value of the Microsoft Power Platform Completed on 11/7/2023 Badge Work with analytics and reporting in finance and operations apps Completed on 11/7/2023 Badge Data integrations with finance and operations apps Completed on 11/7/2023 Badge Identify data integration patterns and scenarios in finance and operations apps Completed on 11/7/2023 Badge Consume business events in finance and operations apps Completed on 11/7/2023 Badge Explore extensions and the extension framework in finance and operations apps Completed on 11/7/2023 Badge Implement application lifecycle management in finance and operations apps Completed on 11/7/2023 Badge Prepare data for migration to finance and operations apps Completed on 11/7/2023 Badge Work with data management in finance and operations apps Completed on 11/7/2023 Badge Perform user acceptance testing in finance and operations apps Completed on 11/7/2023 Badge Design and plan an implementation of finance and operations apps Completed on 11/7/2023 Badge Get started with Lifecycle Services for finance and operations apps Completed on 11/7/2023 Badge FastTrack Customer Success Program for finance and operations Completed on 11/7/2023 Badge Get started with a finance and operations implementation project Completed on 11/7/2023 Badge Use approval workflows in Dynamics 365 Business Central Completed on 11/7/2023 Badge Create workflows in Dynamics 365 Business Central Completed on 11/7/2023 Badge Migrate on-premises data to Dynamics 365 Business Central Completed on 11/7/2023 Badge Migrate data to Business Central Completed on 11/7/2023 Badge Create new companies in Business Central Completed on 11/7/2023 Badge Administer Dynamics 365 Business Central online Completed on 11/7/2023 Badge Integrate Business Central with Outlook Completed on 11/7/2023 Badge Set up email in Dynamics 365 Business Central Completed

on 11/7/2023 Badge Manage users and implement security in Business Central Completed on 11/7/2023 Badge Administer Microsoft Power Platform subscriptions Completed on 11/7/2023 Badge Manage Microsoft Power Platform deployments Completed on 11/7/2023 Badge Use administration options for Dataverse Completed on 11/7/2023 Badge Get started with security roles in Dataverse Completed on 11/7/2023 Badge Authentication and user management in Power Pages Completed on 11/7/2023 Badge Integrate Power Pages with web-based technologies Completed on 11/7/2023 Badge Power Pages administration Completed on 11/7/2023 Badge Power Pages maintenance and troubleshooting Completed on 11/7/2023 Badge Run a Power Automate for desktop flow in unattended mode Completed on 11/7/2023 Badge Use the Teams connector in Power Automate Completed on 11/7/2023 Badge Use AI Builder to process invoice forms in Power Automate Completed on 11/7/2023 Badge Integrate desktop flows with Outlook connector in Power Automate for desktop Completed on 11/7/2023 Badge Connect a cloud flow to desktop flows in Power Automate for desktop Completed on 11/7/2023 Badge Define input and output parameters in Power Automate Completed on 11/7/2023 Badge Build your first Power Automate for desktop flow Completed on 11/7/2023 Badge Optimize your business process with process advisor Completed on 11/7/2023 Badge Use AI Builder in Power Automate Completed on 11/7/2023 Badge Use the Admin center to manage environments and data policies in Power Automate Completed on 11/7/2023 Badge Power Automate's deep integration across multiple data sources Completed on 11/7/2023 Badge Build flows to manage user information Completed on 11/7/2023 Badge Build approval flows with Power Automate Completed on 11/7/2023 Badge Get started with Power Automate Completed on 11/7/2023 Badge Get data with Power BI Desktop Completed on 11/7/2023 Badge Secure, publish, and share data in Power BI Completed on 11/7/2023 Badge Design interactive data experiences with Power BI Desktop Completed on 11/7/2023 Badge Transition from Excel to Power BI Completed on 11/7/2023 Badge Introduction to foundations in data modeling Completed on 11/7/2023 Badge Automate data cleaning with Power Query Completed on 11/7/2023 Badge Introduction to modern analytics using Excel and Power BI Completed on 11/7/2023 Badge Describe the capabilities of Microsoft Power BI Completed on 11/7/2023 Badge Explore fundamentals of data visualization Completed on 11/7/2023 Badge Explore fundamentals of real-time analytics Completed on 11/7/2023 Badge Explore fundamentals of large-scale analytics Completed on 11/7/2023 Badge Explore data roles and services Completed on 11/7/2023 Badge Explore core data concepts Completed on 11/7/2023 Badge Automate multi-container Kubernetes deployments with Azure Pipelines Completed on 11/7/2023 Badge Automate Docker container deployments with Azure Pipelines Completed on 11/7/2023 Badge Automate Azure Functions deployments with Azure Pipelines Completed on 11/7/2023 Badge Manage release cadence in Azure Pipelines by using deployment patterns Completed on 11/7/2023 Badge Run nonfunctional tests in Azure Pipelines Completed on 11/7/2023 Badge Run functional tests in Azure Pipelines Completed on 11/7/2023 Badge Create a multistage pipeline by using Azure Pipelines Completed on 11/7/2023 Badge Create a release pipeline in Azure Pipelines Completed on 11/7/2023 Badge Host your own build agent in Azure Pipelines Completed on 11/7/2023 Badge Manage build dependencies with Azure Artifacts Completed on 11/7/2023 Badge Run quality tests in your build pipeline by using Azure Pipelines Completed on 11/7/2023 Badge Create a build pipeline with Azure Pipelines Completed on 11/7/2023 Badge Explore Azure Pipelines Completed on 11/7/2023 Badge Learn continuous integration with GitHub Actions Completed on 11/7/2023 Badge Introduction to GitHub Actions Completed on 11/7/2023 Badge Work with Azure Repos and GitHub Completed on 11/7/2023 Badge Describe types of source control systems Completed on 11/7/2023 Badge Introduction to source control Completed on 11/7/2023 Badge Plan Agile with GitHub Projects and Azure Boards Completed on 11/7/2023 Badge Choose the DevOps tools Completed on 11/7/2023 Badge Describe team structures Completed on 11/7/2023 Badge Choose the right project Completed on 11/7/2023 Badge Introduction to DevOps Completed on 11/7/2023 Badge Independent learning with math tools in OneNote Completed on 11/6/2023 Badge OneNote Class Notebook: A teacher's all-in-one notebook for students Completed on 11/6/2023 Badge Converse, collaborate, and build community in Teams Completed on 11/6/2023 Badge Organize content, create assignments, and assess learners' understanding in Teams Completed on 11/6/2023 Badge Collaborate with colleagues through live Teams meetings and OneNote Completed on 11/6/2023 Badge Work collaboratively with Staff and PLC Teams Completed on 11/6/2023 Badge Assemble learners and staff with Microsoft Teams meetings Completed on 11/6/2023 Badge Explore the benefits of becoming a Microsoft Educator Trainer Completed on 11/6/2023 Badge Engage and amplify with Flip Completed on 11/6/2023 Badge OneNote Staff Notebook: Tools for staff collaboration Completed on 11/6/2023 Badge Digital storytelling with Microsoft Sway Completed on 11/6/2023 Badge Create authentic assessments with Microsoft Forms Completed on 11/6/2023 Badge Engage teachers and students with Windows 11 and Windows 11 SE: Course 201 Completed on 11/6/2023 Badge Empower school leaders and tech-savvy educators with Windows 11 and Windows 11 SE: Course 101 Completed on 11/6/2023 Badge Get started with OneNote Completed on 11/6/2023 Badge Flipped instruction with PowerPoint Recorder Completed on 11/6/2023 Badge Structure Teams through channels, tabs, files, and apps Completed on 11/6/2023 Badge Empower every student with an inclusive classroom Completed on 11/6/2023 Badge Accessibility: Build the foundation for inclusive learning Completed on 11/6/2023 Badge Teach forward: Best strategies for hybrid, remote, and blended learning Completed on 11/6/2023 924. Badge Empower educators to explore the potential of artificial intelligence oCompleted on 11/6/2023 Previous Versions Blog Contribute Privacy Terms of Use Trademarks © Microsoft 2025 completed Products Find a product .NET Azure Dynamics 365 Excel GitHub HoloLens Industry Solutions Microsoft 365 Microsoft Authentication Library Microsoft Copilot Microsoft Defender Microsoft Endpoint Manager Microsoft Entra Microsoft Fabric Microsoft Graph Microsoft Intune Microsoft Power Platform Microsoft Priva Microsoft Purview Microsoft Teams Microsoft Viva Office 365 OneDrive OneNote Outlook PowerPoint Quantum Development Kit SQL Server Surface Visual Studio Visual Studio App Center Visual Studio Code Windows Windows Server Word Roles Find a role Administrator AI Edge Engineer AI Engineer App Maker Auditor Business Analyst Business Owner Business User Data Analyst Data Engineer Data Scientist Database Administrator Developer DevOps Engineer Functional Consultant Higher Education Educator Information Protection and Compliance Administrator K-12 Educator Network Engineer Privacy Manager Risk Practitioner School Leader Security Engineer Security Operations Analyst Service Adoption Specialist Solution Architect Startup Founder Student Support Engineer Technology Manager Levels Beginner Intermediate Advanced Subjects Find a subject Application development Artificial intelligence Business applications Data management Security anscript

Records may take up to 24 hours to update. Transcript Legal name: Tshingombe Tshitadi Fiston 46307064 Edit display name in settings Username: 46307064 Edit user name in settings Contact email: tshingombefiston@gmail.com Edit contact email in settings Modules completed 924 Training hours completed 738 hr 43 min Modules completed N/A in the module assessment result column means either the module assessment doesn't exist or there's no pass record for it. All modules in this table are complete. Module title Description Completed on Duration Module Assessment Result Introduction to Azure Load Balancer This module explains what Azure Load Balancer does, how it works, and when you should choose to use Load Balancer as a solution to meet your organization's needs. Jan 10, 2025 18 min N/A Enhance your service availability and data locality by using Azure Traffic Manager Discover how Azure Traffic Manager provides DNS load balancing for your application to improve the performance and availability of your application. Jan 10, 2025 29 min N/A Improve your reliability with modern operations practices: An introduction Discover a map for navigating reliability challenges and sustainably achieving the appropriate level of reliability in your systems, services, and products. Jan 10, 2025 10 min N/A Expand your AI skills based on your role Get ready to use Copilot and build AI apps. Discover the transformational experiences you can implement by using Microsoft's AI apps and services. Select a role to explore focused skilling resources. Developer Business or technical leader Business user IT professional Data scientist Data professional Low-code developer Security professional Developer Accelerate app development by using GitHub Copilot Find out how to use GitHub Copilot to interpret and document code, author new code features more efficiently, and refactor, debug, and test code. Build AI apps with Azure Services and best practices Get the details on designing and building a cloud-native AI app, developing a back-end database, and integrating Azure AI services into applications. Build and extend copilots with Microsoft Copilot Studio Use Microsoft Copilot Studio to create conversational AI solutions, and learn how to build actions that extend Microsoft 365 Copilot. Extend Microsoft 365 Copilot (for developers) Use Copilot Studio actions, and learn about building plugins and connectors for Microsoft 365 Copilot. Discover how to choose the right option for your use case. Thank you for your interest in Microsoft! Inbox Microsoft Recruiting Unsubscribe Thu, Feb 27, 9:00 PM (15 hours ago) to me Hi Fiston Tshingombe teodor, Thank you for your interest in a career at Microsoft. Unfortunately, we will not be moving forward with your candidacy for the position of Design Verification Engineer II, 1776092 at this time. However, we'd like to encourage you to continue to explore other career opportunities on Microsoft Careers as we continually update openings on a daily basis. We look forward to considering you for other positions at Microsoft! Thank you, Microsoft Recruiting Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. This mail is sent from an unmonitored mailbox. Please do not reply. This message was sent to tshingombefiston@gmail.com. If you don't want to receive these emails from this company in the future, please go to: https://ms.icims.com/icims2/?r=11B617365170&contactId=129540225 Thank you for your interest in Microsoft! Inbox Microsoft Recruiting Unsubscribe Thu, Feb 27, 9:00 PM (15 hours ago) to me Hi Fiston Tshingombe teodor, Thank you for your interest in a career at Microsoft. Unfortunately, we will not be moving forward with your candidacy for the position of Design Verification Engineer II, 1776092 at this time. However, we'd like to encourage you to continue to explore other career opportunities on Microsoft Careers as we continually update openings on a daily basis. We look forward to considering you for other positions at Microsoft! Thank you, Microsoft Recruiting Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. This mail is sent from an unmonitored mailbox. Please do not reply. This message was sent to tshingombefiston@gmail.com. If you don't want to receive these emails from this company in the future, please go to: https://ms.icims.com/icims2/?r=11B617365170&contactId=129540225

Access Control and Identity Management, 3rd Ed. by Mike Chapple. Publisher: Jones and Bartlett Learning. (Sep, 2020). Building an Information Security Awareness Program, 1st Ed. by Bill Gardner and Valerie Thomas. Publisher: Syngress. (Aug, 2014). Business Continuity and Disaster Recovery Planning for IT Professionals, 2nd Ed. by Susan Snedaker. Publisher: Syngress. (Sep, 2013). Cybersecurity Risk Management by Cynthia Brumfield, Brian Haugli. Publisher: Wiley. (Dec, 2021). Digital Forensics and Incident Response, 2nd Ed. by Gerard Johansen. Publisher: Packt Publishing. (Jan, 2020). Disaster Recovery, Crisis Response, and Business Continuity: A Management Desk Reference by Jamie Watters, Janet Watters. Publisher: Apress. (Dec, 2013). Distributed Denial of Service (DDoS) by Eric Chou, Rich Groves. Publisher: O'Reilly Media, Inc. (Apr, 2018). Foundations of Information Security: A Straightforward Introduction by Jason Andress. Publisher: William Pollock. (Oct, 2019). Fundamentals of Information Systems Security, 4th Ed. by David Kim, Michael G. Solomon. Publisher: Jones & Bartlett Publishers. (Nov, 2021). Information Assurance Handbook: Effective Computer Security and Risk Management Strategies, 1st Ed. by Corey Schou and Steven Hernandez. Publisher: McGraw-Hill Education. (Sep, 2014). Information Security Policies, Procedures, and Standards: A Practitioner's Reference by Dogulas J. Landoll. Publisher: Auerbach Publications. (Mar, 2017). ISC2 Code of Ethics by ISC2. (Dec, 2023). Mastering Windows Security and Hardening by Mark Dunkerley, Matt Tumbarello. Publisher: Packt Publishing. (Aug, 2022). Modern Cryptography for Security Professionals, 1st Ed. by Lisa Bock. Publisher: Packt Publishing. (Jun, 2021). Network Security, Firewalls, and VPNs, 3rd Edition by J. Michael Stewart, Denise Kinsey. Publisher: Jones & Bartlett Learning. (Oct, 2020). Networking Fundamentals, 1st Ed. by Gordon Davies. Publisher: Packt Publishing. (Dec, 2019). Network Security Strategies by Aditya Mukherjee. Publisher: Packt Publishing. (Nov, 2020). NIST SP 800-53, Rev. 5, Security and Privacy Controls for Information Systems and Organizations by Joint Task Force Transformation Initiative. (Sep, 2020). NIST SP 800-61, Rev. 2, Computer Security Incident Handling Guide by Paul Cichonski, Tom Millar, Tim Grance, Karen Scarfone. (Aug, 2012). Security Policies and Implementation Issues, 3rd Ed. by Robert Johnson and Chuck Easttom. Publisher: Bartlett Learning. (Oct, 2020). The Complete Guide to Physical Security by Paul R. Baker and Daniel J. Benny. Publisher: Auerbach Publications. (Apr, 2016). A Practical Guide to TPM 2.0: Using the New Trusted Platform Module in the New Age of Security by Will Arthur, David Challener. Publisher: Apress. (Jan, 2015). Access Control and Identity Management, 3rd Ed. by Mike Chapple. Publisher: Jones and Bartlett Learning. (Sep, 2020). A Technical Guide to IPSec Virtual Private Networks by James S. Tiller. Publisher: Auerbach Publications. (Jul, 2017). Applied Cryptography: Protocols, Algorithms and Source Code in C, 20th Anniversary Ed. by Bruce Schneier. Publisher: Wiley. (Mar, 2015). Building an Information Security Awareness Program, 1st Ed. by Bill Gardner and Valerie Thomas. Publisher: Syngress. (Aug, 2014). Business Continuity and Disaster Recovery Planning for IT Professionals, 2nd Ed. by Susan Snedaker. Publisher: Syngress. (Sep, 2013). Cryptography and Network Security Principles and Practice, 6th Ed. by William Stallings. Publisher: Pearson. (Mar, 2013). Cybersecurity Incident Response: How to Contain, Eradicate, and Recover from Incidents by Eric C. Thompson. Publisher: Apress. (Sep, 2018). Digital Forensics and Incident Response, 2nd Ed. by Gerard Johansen. Publisher: Packt Publishing. (Jan, 2020). Foundations of Information Security: A Straightforward Introduction by Jason Andress. Publisher: William Pollock. (Oct, 2019). Fundamentals of Information Systems Security, 4th Ed. by David Kim, Michael G. Solomon. Publisher: Jones & Bartlett Publishers. (Nov, 2021). Identity Attack Vectors: Implementing an Effective Identity and Access Management Solution by Darran Rolls, Morey J. Haber. Publisher: Apress. (Dec, 2019). Identity and Access Management: Business Performance Through Connected Intelligence, 1st Ed. by Ertem Osmanoglu. Publisher: Syngress. (Nov, 2013). Information Risk Management: A Practitioner's Guide by David Sutton. Publisher: BCS, The Chartered Institute for IT. (Nov, 2014). Introduction to Computer Networks and Cybersecurity, 1st Ed. by J. Chwan-Hwa Wu, David Irwin. Publisher: CRC Press. (Apr, 2016). ISC2 Code of Ethics by ISC2. (Dec, 2023). Logging and Log Management by A. Chuvakin, K. Schmidt. Publisher: Syngress. (Dec, 2012). Network Security, Firewalls, and VPNs, 3rd Edition by J. Michael Stewart, Denise Kinsey. Publisher: Jones & Bartlett Learning. (Oct, 2020). Networking Fundamentals, 1st Ed. by Gordon Davies. Publisher: Packt Publishing. (Dec, 2019). NIST SP 800-61, Rev. 2, Computer Security Incident Handling Guide by Paul Cichonski, Tom Millar, Tim Grance, Karen Scarfone. (Aug, 2012). Official (ISC)² SSCP CBK Reference, 5th Ed. by Mike Wills. Publisher: Sybex. (Dec, 2019). Practical Cloud Security: A Guide for Secure Design and Deployment by Chris Dotson. Publisher: O'Reilly Media. (Mar, 2019). A Practical Guide to TPM 2.0: Using the New Trusted Platform Module in the New Age of Security by Will Arthur, David Challener. Publisher: Apress. (Jan, 2015). Access Control, Authentication, and Public Key Infrastructure (Information Systems Security & Assurance), 1st Ed. by Bill Ballad, Tricia Ballad, Erin Banks. Publisher: Jones & Bartlett Learning. (Oct, 2010). Agile Application Security by Laura Bell, Rich Smith, Michael Brunton-Spall, Jim Bird. Publisher: O'Reilly Media, Inc. (Jun, 2017). Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, and IaaS) by Michael Kavis. Publisher: Wiley. (Jan, 2014). Asset Attack Vectors: Building Effective Vulnerability Management Strategies to Protect Organizations by Morey J. Haber, Brad Hibbert. Publisher: Apress. (Jun, 2018). Business Continuity and Disaster Recovery Planning for IT Professionals, 2nd Ed. by Susan Snedaker. Publisher: Syngress. (Sep, 2013). Computer and Information Security Handbook, 3rd Ed. by John Vacca. Publisher: Morgan Kaufmann. (May, 2017). Computer Security: Art and Science, 2nd Ed. by Matt Bishop. Publisher: Addison-Wesley Professional. (Nov, 2018). Core Software Security: Security at the Source by Anmol Misra, James F. Ransome. Publisher: Auerbach Publications. (Oct, 2018). Data Center Handbook, 2nd Ed. by Hwaiyu Geng. Publisher: Wiley. (May, 2021). Developing Cybersecurity Programs and Policies, 3rd Ed. by Omar Santos, Sari Greene. Publisher: Pearson IT Certification. (Aug, 2018). Disaster Recovery, Crisis Response, and Business Continuity: A Management Desk Reference by Jamie Watters, Janet Watters. Publisher: Apress. (Dec, 2013). Distributed Denial of Service (DDoS) by Eric Chou, Rich Groves. Publisher: O'Reilly Media, Inc. (Apr, 2018). DomainKeys Identified Mail (DKIM) Signature by Murray Kucherawy, Dave Crocker, Tony Hansen. Publisher: IETF. (Sep, 2011). Ethical Hacking and Penetration Testing Guide by Rafay Baloch. Publisher: Auerbach Publications. (Sep, 2017). Federated Identity Primer, 1st Ed. by Derrick Rountree. Publisher: Syngress. (Dec, 2012). Foundations of Information Security: A Straightforward Introduction by Jason Andress. Publisher: William Pollock. (Oct, 2019). Fundamental Practices for Secure Software Development: Essential Elements of a Secure Development Lifecycle Program, 3rd Ed. by Toni Rice. Publisher: SAFECode. (Mar, 2018). Fundamentals of Information Systems Security, 4th Ed. by David Kim, Michael G. Solomon. Publisher: Jones & Bartlett Publishers. (Nov, 2021). EU General Data Protection Regulation (GDPR) by European Parliament. Publisher: European Parliament and Council of the European Union. (May, 2016). Identity and Access Management: Business Performance Through Connected Intelligence, 1st Ed. by Ertem Osmanoglu. Publisher: Syngress. (Nov, 2013). Identity Attack Vectors: Implementing an Effective Identity and Access Management Solution by Darran Rolls, Morey J. Haber. Publisher: Apress. (Dec, 2019). Information Assurance Handbook: Effective Computer Security and Risk Management Strategies, 1st Ed. by Corey Schou and Steven Hernandez. Publisher: McGraw-Hill Education. (Sep, 2014). Information Security Handbook by Darren Death. Publisher: Packt Publishing. (Dec, 2017). Information Security Policies, Procedures, and Standards: A Practitioner's Reference by Dogulas J. Landoll. Publisher: Auerbach Publications. (Mar, 2017). Introduction to Computer Networks and Cybersecurity, 1st Ed. by J. Chwan-Hwa Wu, David Irwin. Publisher: CRC Press. (Apr, 2016). ISC2 Code of Ethics by ISC2. (Dec, 2023). IT Auditing Using Controls to Protect Information Assets, 3rd Edition by Mike Kegerreis, Mike Schiller, Chris Davis. Publisher: McGraw-Hill Education. (Oct, 2019). Network Security, Firewalls, and VPNs, 3rd Edition by J. Michael Stewart, Denise Kinsey. Publisher: Jones & Bartlett Learning. (Oct, 2020). Network Vulnerability Assessment: Identify Security Loopholes in Your Network's Infrastructure by Sagar Rahalkar. Publisher: Packt Publishing. (Aug, 2018). Networking Fundamentals, 3rd Ed. by Chuck Easttom, Richard M. Roberts. Publisher: Goodheart-Willcox. (Sep, 2018). NIST SP 800-30, Rev. 1, Guide for Conducting Risk Assessments by Joint Task Force Transformation Initiative. (Sep, 2012). NIST SP 800-34 Rev. 1, Contingency Planning Guide for Federal Information Systems by Marianne Swanson, Pauline Bowen, Amy Wohl Phillips, Dean Gallup, David Lynes. (May, 2010). NIST SP 800-41, Revision 1, Guidelines on Firewalls and Firewall Policy by Karen Scarfone, Paul Hoffman. (Sep, 2009). NIST SP 800-53, Rev. 5, Security and Privacy Controls for Information Systems and Organizations by Joint Task Force Transformation Initiative. (Sep, 2020). NIST SP 800-63-3, Digital Identity Guidelines: Enrollment and Identity Proofing by Paul A. Grassi, James L. Fenton, Naomi B. Lefkovitz, Jamie M. Danker, Yee-Yin Choong, Kristen K. Greene, Mary F. Theofanos. (Jun, 2017). NIST SP 800-77, Revision 1, Guide to IPsec VPNs by Elaine Barker, Quynh Dang, Sheila Frankel, Karen Scarfone, Paul Wouters. Publisher: NIST. (Jun, 2020). NIST SP 800-88, Guidelines for Media Sanitization by Richard Kissel, Andrew Regenscheid, Matthew Scholl, Kevin Stine. (Dec, 2014). NIST SP 800-95, Guide to Secure Web Services by Anoop Singhal, Theodore Winograd, Karen Scarfone. (Aug, 2007). NIST SP 800-115, Technical Guide to Information Security Testing and Assessment by Karen Scarfone, Murugiah Souppaya, Amanda Cody, Angela Orebaugh. (Sep, 2008). NIST SP 800-122, Guide to Protecting the Confidentiality of Personally Identifiable Information (PII) by Erika McCallister, Tim Grance, Karen Scarfone. (Apr, 2010). NIST SP 800-128, Guide for Security-Focused Configuration Management of Information Systems by Arnold Johnson, Kelley Dempsey, Ron Ross, Sarbari Gupta, Dennis Bailey. (Aug, 2011). NIST SP 800-137, Information Security Continuous Monitoring (ISCM) for Federal Information Systems and Organizations by Kelley Dempsey, Nirali Shah Chawla, Arnold Johnson, Ronald Johnston, Alicia Clay Jones, Angela Orebaugh, Matthew Scholl, Kevin Stine. (Sep, 2011). NIST SP 800-160, Vol. 1, Systems Security Engineering: Considerations for a Multidisciplinary Approach in the Engineering of Trustworthy Secure Systems by Ron Ross, Michael McEvilley, Janet Carrier Oren. (Mar, 2018). Official (ISC)² Guide to the CISSP CBK, 5th Ed. by John Warsinske, Mark Graff, Kevin Henry, Christopher Hoover, Ben Malisow, Sean Murphy, C. Paul Oakes, George Pajari, Jeff T. Parker, David Seidl and Mike Vasquez. Publisher: Wiley. (May, 2019). OWASP Testing Guide, Release 4.0 by Matteo Meucci, Andrew Muller. Publisher: OWASP. (Dec, 2014). Physical Security and Safety by Jeffrey Dingle, Bobby E. Ricks, Truett A, Ricks. Publisher: CRC Press. (Oct, 2014). Practical Cloud Security: A Guide for Secure Design and Deployment by Chris Dotson. Publisher: O'Reilly Media. (Mar, 2019). Practical Internet of Things Security, 2nd Ed. by Brian Russel, Drew Van Duren. Publisher: Packt Publisher. (Nov, 2018). Securing Open Source Libraries by Guy Podjarny. Publisher: O'Reilly Media, Inc. (Nov, 2017). Securing VoIP, 1st Ed. by Regis Bates. Publisher: Syngress. (Nov, 2014). Security Policies and Implementation Issues, 3rd Ed. by Robert Johnson and Chuck Easttom. Publisher: Bartlett Learning. (Oct, 2020). Security Risk Assessment: Managing Physical and Operational Security by John M. White. Publisher: Butterworth-Heinemann. (Jul, 2014). Solving Identity Management in Modern Applications: Demystifying OAuth 2.0, OpenID Connect, and SAML 2.0 by Abhishek Hingnikar, Yvonne Wilson. Publisher: Apress. (Nov, 2022). The Complete Guide to Physical Security by Paul R. Baker and Daniel J. Benny. Publisher: Auerbach Publications. (Apr, 2016). The Disaster Recovery Handbook, 3rd Ed. by Michael Wallace, Lawrence Webber. Publisher: AMACOM. (Dec, 2017). Threat Modeling: Designing for Security, 1st Ed. by Adam Shostack. Publisher: Wiley. (Feb, 2014). Web Application Security: Exploitation and Countermeasures for Modern Web Applications by Andrew Hoffman. Publisher: O'Reilly Media, Inc. (Mar, 2020). Zero Trust Networks: Building Secure Systems in Untrusted Networks by Evan Gilman, Doug Barth. Publisher: O'Reilly. (Jul, 2017). Architecting Cloud Computing Solutions by Kevin L. Jackson and Scott Goessling. Publisher: Packt Publishing. (May, 2018). Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, and IaaS) by Michael Kavis. Publisher: Wiley. (Jan, 2014). Business Continuity and Disaster Recovery Planning for IT Professionals, 2nd Ed. by Susan Snedaker. Publisher: Syngress. (Sep, 2013). Cloud Computing Design Patterns by Thomas Erl, Robert Cope, Amin Naserpour. Publisher: Prentice Hall. (Mar, 2017). Cloud Security Handbook by Eyal Estrin. Publisher: Packt Publishing. (Apr, 2022). Data Governance: The Definitive Guide by Evren Eryurek, Uri Gilad, Valliappa Lakshmanan, Anita Kibunguchy-Grant, Jessi Ashdown. Publisher: O'Reilly Media, Inc. (Mar, 2021). EU General Data Protection Regulation (GDPR) by European Parliament. Publisher: European Parliament and Council of the European Union. (May, 2016). Fundamental Practices for Secure Software Development. Publisher: SAFECode. (Mar, 2018). Guide to Privacy and Security of Electronic Health Information. Publisher: HealthIT.gov. (Apr, 2015). Incident Response in the Age of Cloud: Techniques and best practices to effectively respond to cybersecurity incidents by Erdal Ozkaya. Publisher: Packt Publishing. (Feb, 2021). Information Security Handbook by Darren Death. Publisher: Packt Publishing. (Dec, 2017). NIST SP 800-125, Guide to Security for Full Virtualization Technologies by Karen Scarfone, Murugiah Souppaya, Paul Hoffman. (Jan, 2011). Official (ISC)² Guide to the CCSP CBK, 3rd Ed. by Leslie Fife, Aaron Kraus, Bryan Lewis. Publisher: Sybex. (July, 2021). Practical Cloud Security: A Guide for Secure Design and Deployment by Chris Dotson. Publisher: O'Reilly Media. (Mar, 2019). Security Guidance for Critical Areas of Focus in Cloud Computing v4.0 by Rich Mogull, James Arlen, Adrian Lane, Gunnar Peterson, Mike Rothman, David Mortman. Publisher: Cloud Security Alliance. (Jul, 2017). Security, Privacy, and Digital Forensics in the Cloud by Lei Chen, Hassan Takabi, Nhien-An Le-Khac. Publisher: Wiley. (Apr, 2019). Information Security Risk Management for ISO 27001/ISO 27002, 3rd Ed. by Alan Calder, Steve Watkins. Publisher: IT Governance Publishing. (Aug, 2019). ISO 27001/ISO 27002, A Pocket Guide, 2nd Ed. By Alan Calder. Publisher: IT Governance Publishing. (Oct, 2013). NIST FIPS-199, Standards for Security Categorization of Federal Information and Information Systems by U.S. Dept. of Commerce. (Feb, 2004). NIST SP 800-18, Rev. 1, Guide for Developing Security Plans for Federal Information Systems by Marianne Swanson, Joan Hash, Pauline Bowen. (Feb, 2006). NIST SP 800-30, Rev. 1, Guide for Conducting Risk Assessments by Joint Task Force Transformation Initiative. (Sep, 2012). NIST SP 800-37, Rev. 2, Risk Management Framework for Information Systems and Organizations: A System Life Cycle Approach for Security and Privacy by Joint Task Force Transformation Initiative. (Dec, 2018). NIST SP 800-39, Managing Information Security Risk: Organization, Mission, and Information System View by Joint Task Force Transformation Initiative. (Mar, 2011). NIST SP 800-53, Rev. 5, Security and Privacy Controls for Information Systems and Organizations by Joint Task Force Transformation Initiative. (Sep, 2020). NIST SP 800-53A, Rev. 5, Assessing Security and Privacy Controls in Information Systems and Organizations by Joint Task Force Transformation Initiative. (Jan, 2022). NIST SP 800-53B, Control Baselines for Information Systems and Organizations by Joint Task Force Transformation Initiative. (Sep, 2020). NIST SP 800-60, Vol. 1, Rev. 1, Guide for Mapping Types of Information and Information Systems to Security Categories by Kevin Stine, Rich Kissel, William C. Barker, Jim Fahlsing, Jessica Gulick. (Aug, 2008). NIST SP 800-70, Rev. 4, National Checklist Program for IT Products: Guidelines for Checklist Users and Developers by Stephen D. Quinn, Murugiah Souppaya, Melanie Cook, Karen Scarfone. (Feb, 2018). NIST SP 800-88, Guidelines for Media Sanitization by Richard Kissel, Andrew Regenscheid, Matthew Scholl, Kevin Stine. (Dec, 2014). NIST SP 800-137, Information Security Continuous Monitoring (ISCM) for Federal Information Systems and Organizations by Kelley Dempsey, Nirali Shah Chawla, Arnold Johnson, Ronald Johnston, Alicia Clay Jones, Angela Orebaugh, Matthew Scholl, Kevin Stine. (Sep, 2011). A Guide to Building Secure Web Applications and Web Services 2.0 Black Hat Ed. by Abraham Kang, Adrian Wiesmann, et al. Publisher: OWASP. (Jul, 2005). A Practical Guide to TPM 2.0: Using the New Trusted Platform Module in the New Age of Security by Will Arthur, David Challener. Publisher: Apress. (Jan, 2015). Access Control, Authentication, and Public Key Infrastructure, 2nd Ed. by Mike Chapple, Bill Ballad, Tricia Ballad, Erin Banks. Publisher: Jones & Bartlett Learning. (Jul, 2013). Agile Application Security by Laura Bell, Rich Smith, Michael Brunton-Spall, Jim Bird. Publisher: O'Reilly Media, Inc. (Jun, 2017). Applied Cryptography: Protocols, Algorithms and Source Code in C, 20th Anniversary Ed. by Bruce Schneier. Publisher: Wiley. (Mar, 2015). CMMI for Development: Implementation Guide by Mukund Chaudhary, Abhishek Chopra. Publisher: Apress. (Dec, 2016). Computer Security: Art and Science, 2nd Ed. by Matt Bishop. Publisher: Addison-Wesley Professional. (Nov, 2018). Core Software Security: Security at the Source by Anmol Misra, James F. Ransome. Publisher: Auerbach Publications. (Oct, 2018). Cybersecurity - Attack and Defense Strategies, 2nd Ed. by Erdal Ozkaya and Yuri Diogenes. Publisher: Packt Publishing. (Dec, 2019). Enterprise Software Security: A Confluence of Disciplines by Kenneth R. van Wyk, Mark G. Graff, Dan S. Peters, Diana L. Burley. Publisher: Addison-Wesley Professional. (Dec, 2014). Hacker Techniques, Tools, and Incident Handling, 2nd Ed. by Sean-Philip Oriyano. Publisher: Jones & Bartlett Learning. (Aug, 2013). Hands-On Security in DevOps by Tony Hsu. Publisher: Packt Publishing. (Jul, 2018). Improper Error Handling by Jeremy Ferragamo, Wichers, Jim Bird. Publisher: OWASP. (Dec, 2021). Information Security: Principles and Practices, 2nd Ed. by Mark S. Merkow, Jim Breithaupt. Publisher: Pearson IT Certification. (Jun, 2014). IT Release Management: A Hands-on Guide by Dave Howard. Publisher: CRC Press. (Apr, 2016). IT Security Risk Control Management: An Audit Preparation Plan by Raymond Pompon. Publisher: Apress. (Sep, 2016). Lessons Learned in Software Testing: A Context-Driven Approach by Bret Pettichord, Cem Kaner, James Marcus Bach. Publisher: Wiley. (Dec, 2001). Logging and Log Management by A. Chuvakin, K. Schmidt. Publisher: Syngress. (Dec, 2012). Mastering the Requirements Process: Getting Requirements Right v3.0 by S. Robertson, J. Robertson. Publisher: Addison-Wesley Professional. (Aug, 2012). NIST SP 800-37, Rev. 2, Risk Management Framework for Information Systems and Organizations: A System Life Cycle Approach for Security and Privacy by Joint Task Force Transformation Initiative. (Dec, 2018). NIST SP 800-53, Rev. 5, Security and Privacy Controls for Information Systems and Organizations by Joint Task Force Transformation Initiative. (Sep, 2020). NIST SP 800-60, Vol. 1, Rev. 1, Guide for Mapping Types of Information and Information Systems to Security Categories by Kevin Stine, Rich Kissel, William C. Barker, Jim Fahlsing, Jessica Gulick. (Aug, 2008). NIST SP 800-88, Guidelines for Media Sanitization by Richard Kissel, Andrew Regenscheid, Matthew Scholl, Kevin Stine. (Dec, 2014). NIST IR 7622, Notional Supply Chain Risk Management Practices for Federal Information Systems by Jon Boyens, Celia Paulsen, Nadya Bartol, Stephany A. Shankles, Rama Moorthy. (Oct, 2012). Official (ISC)² Guide to the CSSLP, 2nd Ed. by Mano Paul. Publisher: Auerbach Publications. (Aug, 2013). OWASP Testing Guide, Release 4.0 by Matteo Meucci, Andrew Muller. Publisher: OWASP. (Dec, 2014). Penetration Testing: A Survival Guide by W. Halton, B. Weaver, J. Ansari, S. Kotipalli, M. Imran. Publisher: Packt Publishing. (Jan, 2017). Security Risk Management by Evan Wheeler. Publisher: Syngress. (Apr, 2011). Software Testing Foundations: A Study Guide for the Certified Tester Exam, 4th Ed. by Andreas Spillner. Publisher: Rocky Nook. (Feb, 2014). Web Application Firewalls by Chad Russell. Publisher: O'Reilly Media, Inc. (Apr, 2018). Agile Application Lifecycle Management: Using DevOps to Drive Process Improvement, 1st Ed. by Bob Aiello, Leslie Sachs. Publisher: Addison-Wesley Professional. (Jun, 2016). Agile Application Security by Laura Bell, Rich Smith, Michael Brunton-Spall, Jim Bird. Publisher: O'Reilly Media, Inc. (Jun, 2017). Architecting Secure Software Systems, 1st Ed. by Asoke Talukder, Manish Chaitanya. Publisher: Auerbach Publications. (Sep, 2019). Applied Cryptography: Protocols, Algorithms and Source Code in C, 20th Anniversary Ed. by Bruce Schneier. Publisher: Wiley. (Mar, 2015). Beginning Database Design Solutions by Rod Stephens. Publisher: Jossey-Bass. (Nov, 2008). Business Continuity and Disaster Recovery Planning for IT Professionals, 2nd Ed. by Susan Snedaker. Publisher: Syngress. (Sep, 2013). Cloud Storage Security: A Practical Guide by Aaron Wheeler, Michael Winburn. Publisher: Elsevier. (Jul, 2015). Common Criteria for Information Technology Security Evaluation, Version 3.1 Rev. 5 by Mead, N. Publisher: Carnegie. (Apr, 2017). Data Center Handbook, 2nd Ed. by Hwaiyu Geng. Publisher: Wiley. (May, 2021). Disaster Recovery and Business Continuity, 3rd Ed. by B.S. Thejandra. Publisher: IT Governance Publishing. (Jan, 2014). Enterprise Security Architecture: A Business-Driven Approach, 1st Ed. by John Sherwood. Publisher: CRC Press. (Nov, 2015). Identity and Access Management: Business Performance Through Connected Intelligence, 1st Ed. by Ertem Osmanoglu. Publisher: Syngress. (Nov, 2013). Information Security Management Handbook, Vol. 6, 6th Ed. by Harold F. Tipton and Micki Krause Nozaki. Publisher: Auerbach Publications. (Apr, 2016). Information Security Management Handbook, Vol. 7, 6th Ed. by Richard O'Hanley, James Tiller. Publisher: Auerbach Publications. (Aug, 2013). NIST SP 800-34 Rev. 1, Contingency Planning Guide for Federal Information Systems by Marianne Swanson, Pauline Bowen, Amy Wohl Phillips, Dean Gallup, David Lynes. (May, 2010). NIST SP 800-57, Rev. 5, Recommendation for Key Management: Part 1 – General by Elaine Barker. Publisher: NIST. (May, 2020) . NIST SP 800-61, Rev. 2, Computer Security Incident Handling Guide by Paul Cichonski, Tom Millar, Tim Grance, Karen Scarfone. (Aug, 2012). NIST SP 800-63-3, Digital Identity Guidelines: Enrollment and Identity Proofing by Paul A. Grassi, James L. Fenton, Naomi B. Lefkovitz, Jamie M. Danker, Yee-Yin Choong, Kristen K. Greene, Mary F. Theofanos. (Jun, 2017). NIST SP 800-115, Technical Guide to Information Security Testing and Assessment by Karen Scarfone, Murugiah Souppaya, Amanda Cody, Angela Orebaugh. (Sep, 2008). NIST SP 800-125, Guide to Security for Full Virtualization Technologies by Karen Scarfone, Murugiah Souppaya, Paul Hoffman. (Jan, 2011). NIST SP 800-162, Guide to Attribute Based Access Control (ABAC) Definition and Considerations by Vincent Hu, David Ferraiolo, Rick Kuhn, Adam Schnitzer, Kenneth Sandlin, Robert Miller, Karen Scarfone. (Jan, 2014). Official (ISC)² Guide to the ISSAP CBK, 2nd Ed. by Adam Gordon. Publisher: Auerbach Publications. (Jan, 2017). Payment Card Industry Data Security Standards, Requirements and Security Assessment Procedures, Version 3.2.1 by PCI Security Standards Council. Publisher: PCI Security Standards Council, LLC. (May, 2018). Practical Internet of Things Security, 2nd Ed. by Brian Russel, Drew Van Duren. Publisher: Packt Publisher. (Nov, 2018). SABSA Executive Summary by SABSA. Publisher: The SABSA Institute. (Dec, 2021). Secure Coding in C and C++, 2nd Ed. by Robert Seacord. Publisher: Addison-Wesley Professional. (Apr, 2013). Security Patterns in Practice: Designing Secure Architectures Using Software Patterns by Eduardo Fernandez-Buglioni. Publisher: Wiley. (May, 2013). Security Guidance for Critical Areas of Focus in Cloud Computing v4.0 by Rich Mogull, James Arlen, Adrian Lane, Gunnar Peterson, Mike Rothman, David Mortman. Publisher: Cloud Security Alliance. (Jul, 2017). A Guide to the Project Management Body of Knowledge (PMBOK Guide), 7th Ed. by Project Management Institute. Publisher: Project Management Institute. (Aug, 2021). INCOSE Systems Engineering Handbook by Walden. Publisher: Wiley. (Jul, 2015). Information Assurance Technical Framework 3.1 by National Security Agency Information Assurance Solutions Technical Directors. (Sep, 2002). ISO/IEC 15408 Common Criteria for Information Technology Security Evaluation by ISO/IEC. Publisher: National Information Assurance Partnership. (Dec, 2017). NIST SP 800-30, Rev. 1, Guide for Conducting Risk Assessments by Joint Task Force Transformation Initiative. (Sep, 2012). NIST SP 800-37, Rev. 2, Risk Management Framework for Information Systems and Organizations: A System Life Cycle Approach for Security and Privacy by Joint Task Force Transformation Initiative. (Dec, 2018). NIST SP 800-39, Managing Information Security Risk: Organization, Mission, and Information System View by Joint Task Force Transformation Initiative. (Mar, 2011). NIST SP 800-40, Rev. 3, Guide to Enterprise Patch Management Technologies Murugiah Souppaya, Karen Scarfone. (Jul, 2013). NIST SP 800-53, Rev. 5, Security and Privacy Controls for Information Systems and Organizations by Joint Task Force Transformation Initiative. (Sep, 2020). NIST SP 800-88, Guidelines for Media Sanitization by Richard Kissel, Andrew Regenscheid, Matthew Scholl, Kevin Stine. (Dec, 2014). NIST SP 800-115, Technical Guide to Information Security Testing and Assessment by Karen Scarfone, Murugiah Souppaya, Amanda Cody, Angela Orebaugh. (Sep, 2008). NIST SP 800-160, Vol. 1, Systems Security Engineering: Considerations for a Multidisciplinary Approach in the Engineering of Trustworthy Secure Systems by Ron Ross, Michael McEvilley, Janet Carrier Oren. (Mar, 2018). NIST SP 800-161, Supply Chain Risk Management Practices for Federal Information System and Organizations by Jon Boyens, Celia Paulsen, Rama Moorthy, Nadya Bartol. (Apr, 2015). A Guide to the Project Management Body of Knowledge (PMBOK Guide), 7th Ed. by Project Management Institute. Publisher: Project Management Institute. (Aug, 2021). Auditing IT Infrastructures for Compliance, 2nd Ed. by Martin Weiss. Publisher: Jones & Bartlett Publishers. (Jul, 2015). Business Continuity and Disaster Recovery Planning for IT Professionals, 2nd Ed. by Susan Snedaker. Publisher: Syngress. (Sep, 2013). Digital Forensics and Incident Response, 2nd Ed. by Gerard Johansen. Publisher: Packt Publishing. (Jan, 2020). Disaster Recovery, Crisis Response, and Business Continuity: A Management Desk Reference by Jamie Watters, Janet Watters. Publisher: Apress. (Dec, 2013). Disaster Recovery Planning: For Computers and Communication Resources by Jon Toigo. Publisher: Wiley. (Jan, 1996). Information Security Management Handbook, Vol. 6, 6th Ed. by Harold F. Tipton and Micki Krause Nozaki. Publisher: Auerbach Publications. (Apr, 2016). ISC2 Code of Ethics by ISC2. (Dec, 2023). Incident Response & Computer Forensics, 3rd Ed. by Jason Luttgens, Matthew Pepe, Kevin Mandia. Publisher: McGraw-Hill Osborne Media. (Aug, 2014). IT Auditing Using Controls to Protect Information Assets, 3rd Edition by Mike Kegerreis, Mike Schiller, Chris Davis. Publisher: McGraw-Hill Education. (Oct, 2019). NIST SP 800-30, Rev. 1, Guide for Conducting Risk Assessments by Joint Task Force Transformation Initiative. (Sep, 2012). NIST SP 800-34 Rev. 1, Contingency Planning Guide for Federal Information Systems by Marianne Swanson, Pauline Bowen, Amy Wohl Phillips, Dean Gallup, David Lynes. (May, 2010). NIST SP 800-37, Rev. 2, Risk Management Framework for Information Systems and Organizations: A System Life Cycle Approach for Security and Privacy by Joint Task Force Transformation Initiative. (Dec, 2018). NIST SP 800-39, Managing Information Security Risk: Organization, Mission, and Information System View by Joint Task Force Transformation Initiative. (Mar, 2011). NIST SP 800-53, Rev. 5, Security and Privacy Controls for Information Systems and Organizations by Joint Task Force Transformation Initiative. (Sep, 2020). NIST SP 800-55, Rev. 1, Performance Measurement Guide for Information Security by Elizabeth Chew, Marianne Swanson, Kevin Stine, Nadya Bartol, Anthony Brown, Will Robinson. (Jul, 2008). NIST SP 800-61, Rev. 2, Computer Security Incident Handling Guide by Paul Cichonski, Tom Millar, Tim Grance, Karen Scarfone. (Aug, 2012). NIST SP 800-128, Guide for Security-Focused Configuration Management of Information Systems by Arnold Johnson, Kelley Dempsey, Ron Ross, Sarbari Gupta, Dennis Bailey. (Aug, 2011). NIST SP 800-160, Vol. 1, Systems Security Engineering: Considerations for a Multidisciplinary Approach in the Engineering of Trustworthy Secure Systems by Ron Ross, Michael McEvilley, Janet Carrier Oren. (Mar, 2018). Official (ISC)² Guide to the ISSMP CBK by Joseph Steinberg and Harold F. Tipton. Publisher: Auerbach Publications. (Apr, 2016). Security Operations Center: Building, Operating, and Maintaining your SOC by Gary McIntyre, Joseph Muniz, Nadhem AlFardan. Publisher: Cisco Press. (Nov, 2015). The Disaster Recovery Handbook, 3rd Ed. by Michael Wallace, Lawrence Webber. Publisher: AMACOM. (Dec, 2017). Threat Modeling: Designing for Security, 1st Ed. by Adam Shostack. Publisher: Wiley. (Feb, 2014).

nline Training Official ISC2 Certified in Cybersecurity (CC) eTextbook eTextbook Description >| Certification Defining the Boundaries of Zero Trust This learning experience invites you to review the set of guiding principles for workflow, system design, and operations that create a zero trust architecture. (2.0 CPE) Top of Form Bottom of Form Top of Form Bottom of Form Software Inventory and SBOM This course invites you to expand your knowledge of how Software Bill of Materials (SBOM) can help cybersecurity professionals effectively mitigate vulnerabilities and ensure compliance. Top of Form Bottom of Form Top of Form Bottom of Form Software Inventory and SBOM This course invites you to expand your knowledge of how Software Bill of Materials (SBOM) can help cybersecurity professionals effectively mitigate vulnerabilities and ensure compliance. Top of Form Bottom of Form Top of Form Bottom of Form Working in the Cloud This course invites you to learn about the range of challenges security professionals face as they work to utilize, optimize and secure critical assets in the cloud. Top of Form Bottom of Form Top of Form Bottom of Form Working in the Cloud This course invites you to learn about the range of challenges security professionals face as they work to utilize, optimize and secure critical assets in the cloud. Top of Form Bottom of Form Top of Form Bottom of Form Moving to the Cloud This course invites you to learn about the strategic and security considerations necessary to transition an organization to cloud computing in alignment with business needs. Top of Form Bottom of Form Top of Form Bottom of Form Moving to the Cloud This course invites you to learn about the strategic and security considerations necessary to transition an organization to cloud computing in alignment with business needs. Top of Form Bottom of Form Top of Form Bottom of Form Cloud Basics This course invites you to learn about essential cloud concepts and principles, including key drivers for use, essential characteristics, and service and deployment models within cloud architectures. Top of Form Bottom of Form Top of Form Bottom of Form Cloud Basics This course invites you to learn about essential cloud concepts and principles, including key drivers for use, essential characteristics, and service and deployment models within cloud architectures. Top of Form Bottom of Form Top of Form Bottom of Form Building Your Personal Brand and Digital Presence This course invites you to review the essentials of building a personal brand and digital presence that reflects your core values, unique strengths and professional aspirations. Top of Form Bottom of Form Top of Form Bottom of Form Resume/CV/Portfolio Building and Management This course invites you to review the critical components of documents such as resumes, CVs and portfolios that showcase your unique strengths and value to potential employers. Top of Form Bottom of Form Top of Form Bottom of Form Identifying and Building Your Network This course invites you to review the critical role networking plays in professional development by unlocking new opportunities, facilitating knowledge sharing and supporting long-term career success. Top of Form Bottom of Form Top of Form Bottom of Form Identifying Your Cyber Path and Industry This course invites you to explore a wide range of opportunities in cybersecurity and plan a skill development path toward a successful career. Top of Form Bottom of Form Top of Form Bottom of Form Nailing the Interview Process This course invites you to review actionable strategies and skills to excel in any interview scenario and stand out from the competition. Top of Form Bottom of Form Top of Form Bottom of Form Managing the Offer and Negotiation Process This course invites you to review the essential knowledge and skills to navigate job offers, negotiate confidently and transition smoothly into new roles. Top of Form Bottom of Form Top of Form Bottom of Form Managing the Offer and Negotiation Process This course invites you to review the essential knowledge and skills to navigate job offers, negotiate confidently and transition smoothly into new roles. Top of Form Bottom of Form Top of Form Bottom of Form Nailing the Interview Process This course invites you to review actionable strategies and skills to excel in any interview scenario and stand out from the competition. Top of Form Bottom of Form Top of Form Bottom of Form Identifying Your Cyber Path and Industry This course invites you to explore a wide range of opportunities in cybersecurity and plan a skill development path toward a successful career. Top of Form Bottom of Form Top of Form Bottom of Form Identifying and Building Your Network This course invites you to review the critical role networking plays in professional development by unlocking new opportunities, facilitating knowledge sharing and supporting long-term career success. Top of Form Bottom of Form Top of Form Bottom of Form Resume/CV/Portfolio Building and Management This course invites you to review the critical components of documents such as resumes, CVs and portfolios that showcase your unique strengths and value to potential employers. Top of Form Bottom of Form Top of Form Bottom of Form 1 2 3 > >| Go to the main content Privacy and Cookies This website stores cookies on your computer which help us make the website work better for you. Collapsed, toggle side navigation to expand Edit my profile Tshingombe Tshingombe Tshitadi ISC2 ID: 1907033 Dashboard My Profile Sign out Find an exam Find an Exam: CC Certified in Cybersecurity (CC) CCSP Certified Cloud Security Professional (CCSP) CGRC Certified in Governance Risk and Compliance CISSP Certified Information Systems Security Professional CSSLP Certified Secure Software Lifecycle Professional ISSAP Information Systems Security Architecture Professional ISSEP Information Systems Security Engineering Professional ISSMP Information Systems Security Management Professional SSCP Systems Security Certified Practitioner Terms Privacy Contact Copyright 1996-2025 Pearson Education Inc. or its affiliate(s). All rights reserved. Certification is Just the Beginning Achieving your certification isn't the end of your journey. ISC2 members and associates are part of a global community of cybersecurity professionals with access to a long list of benefits that include continuing professional education, peer-to-peer networking and exclusive discounts. Stay focused on your goal and make the most of what's ahead. Preview Your Benefits ISC2 625 N Washington Street, Suite 400, Alexandria, VA 22314, United States • www.isc2.org © 1996–2024. ISC2, Inc. All rights reserved. You're receiving this email because you've expressed interest in Certifications, Education Resources and Offers. Click to unsubscribe, or update your subscription preferences on the Member Website. Register for exam Effective Date: September 2024 SSCP Certification Exam Outline View and download the latest PDF version of the SSCP Certification Exam Outline in the following languages: SSCP - English | SSCP - Japanese | SSCP - Spanish About SSCP The Systems Security Certified Practitioner (SSCP) is the ideal certification for those with proven technical skills and practical, hands-on security knowledge in operational IT roles. It provides confirmation of a practitioner's ability to implement, monitor and administer IT infrastructure in accordance with information security policies and procedures that ensure data confidentiality, integrity and availability. The broad spectrum of topics included in the SSCP Common Body of Knowledge (CBK) ensure its relevancy across all disciplines in the field of information security. Successful candidates are competent in the following domains: Security Concepts and Practices Access Controls Risk Identification, Monitoring, and Analysis Incident Response and Recovery Cryptography Network and Communications Security Systems and Application Security Experience Requirements Candidates must have a minimum of one year cumulative work experience in one or more of the domains of the SSCP CBK. A one year prerequisite pathway will be granted for candidates who received a degree (bachelors or masters) in a cybersecurity program. A candidate that doesn't have the required experience to become an SSCP may become an Associate of ISC2 by successfully passing the SSCP examination. The Associate of ISC2 will then have two years to earn the one year required experience. You can learn more about SSCP experience requirements and how to account for part-time work and internships at www.isc2.org/Certifications/SSCP/SSCP-Experience-Requirements. Accreditation SSCP is in compliance with the stringent requirements of ANSI/ISO/IEC Standard 17024. Job Task Analysis (JTA) ISC2 has an obligation to its membership to maintain the relevancy of the SSCP. Conducted at regular intervals, the Job Task Analysis (JTA) is a methodical and critical process of determining the tasks that are performed by security professionals who are engaged in the profession defined by the SSCP. The results of the JTA are used to update the examination. This process ensures that candidates are tested on the topic areas relevant to the roles and responsibilities of today's practicing information security professionals. SSCP Examination Information Length of exam 3 hours Number of items 125 Item format Multiple choice Passing grade 700 out of 1000 points Language availability English, Japanese and Spanish Testing center Pearson VUE Testing Center SSCP Examination Weights Domains Average Weight 1. Security Concepts and Practices 16% 2. Access Controls 15% 3. Risk Identification, Monitoring and Analysis 15% 4. Incident Response and Recovery 14% 5. Cryptography 9% 6. Network and Communications Security 16% 7. Systems and Application Security 15% Total 100% Domains 1.1 - Comply with codes of ethics ISC2 Code of Ethics Organizational code of ethics 1.2 - Understand security concepts Confidentiality Integrity Availability Accountability Non-repudiation Least privilege Segregation of duties (SoD) 1.3 - Identify and implement security controls Technical controls (e.g., firewalls, intrusion detection systems (IDS), access control list (ACL)) Physical controls (e.g., mantraps, cameras, locks) Administrative controls (e.g., security policies, standards, procedures, baselines) Assessing compliance requirements Periodic audit and review 1.4 - Document and maintain functional security controls Deterrent controls Preventative controls Detective controls Corrective controls Compensating controls 1.5 - Support and implement asset management lifecycle (i.e., hardware, software, and data) Process, planning, design and initiation Development /Acquisition (e.g., DevSecOps, testing) Inventory and licensing (e.g., open source, closed-source) Implementation/Assessment Operation/Maintenance/End of Life (EOL) Archival and retention requirements Disposal and destruction 1.6 - Support and/or implement change management lifecycle Change management (e.g., roles, responsibilities, processes, communications, audit) Security impact analysis Configuration management (CM) 1.7 - Support and/or implement security awareness and training (e.g., social engineering/phishing/tabletop exercises/awareness communications) 1.8 - Collaborate with physical security operations (e.g., data center/facility assessment, badging and visitor management, personal device restrictions) 2.1 - Implement and maintain authentication methods Single/Multi-factor authentication (MFA) Single sign-on (SSO) (e.g., Active Directory Federation Services (ADFS), OpenID Connect) Device authentication (e.g., certificate, Media Access Control (MAC) address, Trusted Platform Module (TPM)) Federated access (e.g., Open Authorization 2 (OAuth2), Security Assertion Markup Language (SAML)) 2.2 - Understand and support internetwork trust architectures Trust relationships (e.g., 1-way, 2-way, transitive, zero) Internet, intranet, extranet, and demilitarized zone (DMZ) Third-party connections (e.g., application programming interface (API), app extensions, middleware) 2.3 - Support and/or implement the identity management lifecycle Authorization Proofing Provisioning/De-provisioning Monitoring, Reporting, and Maintenance (e.g., role changes, new security standards) Entitlement (e.g., inherited rights, resources) Identity and access management (IAM) systems 2.4 - Understand and administer access controls Mandatory Discretionary Role-based (e.g., subject-based, object-based, Privileged Access Management (PAM)) Rule-based Attribute-based 3.1 - Understand risk management Risk visibility and reporting (e.g., risk register, sharing threat intelligence, indicators of Compromise (IOC), Common Vulnerability Scoring System (CVSS), socialization, MITRE/ATT&CK model) Risk management concepts (e.g., impact assessments, threat modeling, scope) Risk management frameworks Risk tolerance (e.g., appetite, risk quantification) Risk treatment (e.g., accept, transfer, mitigate, avoid) 3.2 - Understand legal and regulatory concerns (e.g., jurisdiction, limitations, privacy) 3.3 - Perform security assessments and vulnerability management activities Risk management frameworks implementation Security testing Risk review (e.g., internal, supplier, architecture) Vulnerability management lifecycle (e.g., scanning, reporting, analysis, remediation) 3.4 - Operate and monitor security platforms (e.g., continuous monitoring) Source systems (e.g., applications, security appliances, network devices, hosts) Events of interest (e.g., errors, omissions, anomalies, unauthorized changes, compliance violations, policy failures) Log management (e.g., policy, integrity, preservation, architectures, configuration, aggregation, tuning) Security information and event management (SIEM) (e.g., real-time monitoring, analysis, tracking, audit) 3.5 - Analyze monitoring results Security baselines and anomalies (e.g., correlation, noise reduction) Visualizations, metrics, and trends (e.g., notifications, dashboards, timelines) Event data analysis Document and communicate findings (e.g., escalation) 4.1 - Understand and support incident response lifecycle (e.g., National Institute of Standards and Technology (NIST), International Organization for Standardization (ISO)) Preparation (e.g., defining roles, training programs) Detection, analysis, and escalation (e.g., incident communication, public relations) Containment Eradication Recovery (e.g., incident documentation) Post incident activities (e.g., lessons learned, new countermeasures, continuous improvement) 4.2 - Understand and support forensic investigations Legal (e.g., civil, criminal, administrative) and ethical principles Evidence handling (e.g., first responder, triage, chain of custody, preservation of scene) Reporting of analysis Organization Security Policy Compliance 4.3 - Understand and support business continuity plan (BCP) and disaster recovery plan (DRP) Emergency response plans and procedures (e.g., information system contingency, pandemic, natural disaster, crisis management) Interim or alternate processing strategies Restoration planning (e.g., Restore Time Objective (RTO), Restore Point Objectives (RPO), Maximum Tolerable Downtime (MTD)) Backup and redundancy implementation Testing and drills (e.g., playbook, tabletop, disaster recovery exercises, scheduling) 5.1 - Understand reasons and requirements for cryptography Confidentiality Integrity and authenticity Data sensitivity (e.g., personally identifiable information (PII), intellectual property (IP), protected health information (PHI)) Regulatory and industry best practice (e.g., Payment Card Industry Data Security Standards (PCI-DSS), International Organization for Standardization (ISO)) Cryptographic entropy (e.g., quantum cryptography, quantum key distribution) 5.2 - Apply cryptography concepts Hashing Salting Symmetric/Asymmetric encryption/Elliptic curve cryptography (ECC) Non-repudiation (e.g., digital signatures/certificates, Hash-based Message Authentication Code (HMAC), audit trails) Strength of encryption algorithms and keys (e.g., Advanced Encryption Standards (AES), Rivest-Shamir-Adleman (RSA)) Cryptographic attacks and cryptanalysis 5.3 - Understand and implement secure protocols Protocols Common use cases (e.g., credit card processing, file transfer, web client, virtual private network (VPN), transmission of PII data) Limitations and vulnerabilities 5.4 - Understand public key infrastructure (PKI) Fundamental key management concepts (e.g., storage, rotation, composition, generation, destruction, exchange, revocation, escrow) Web of Trust (WOT) (e.g., Pretty Good Privacy (PGP), GNU Privacy Guard (GPG), blockchain) 6.1 - Understand and apply fundamental concepts of networking Open Systems Interconnection (OSI) and Transmission Control Protocol/Internet Protocol (TCP/IP) models Network topologies Network relationships (e.g., peer-to-peer (P2P), client server) Transmission media types (e.g., wired, wireless) Software-defined networking (SDN) (e.g., Software-Defined Wide Area Network (SD-WAN), network virtualization, automation) Commonly used ports and protocols 6.2 - Understand network attacks (e.g., distributed denial of service (DDoS), man-in-the-middle (MITM), Domain Name System (DNS) cache poisoning) Countermeasures (e.g., content delivery networks (CDN), firewalls, network access controls, intrusion detection and prevention systems (IDPS)) 6.3 - Manage network access controls Network access controls, standards and protocols (e.g., Institute of Electrical and Electronics Engineers (IEEE) 802.1X, Remote Authentication Dial-In User Service (RADIUS), Terminal Access Controller Access-Control System Plus (TACACS+)) Remote access operation and configuration (e.g., thin client, virtual private network (VPN), virtual desktop infrastructure (VDI)) 6.4 - Manage network security Logical and physical placement of network devices (e.g., inline, passive, virtual) Segmentation (e.g., physical/logical, data/control plane, virtual local area network (VLAN), access control list (ACL), firewall zones, micro-segmentation) Secure device management 6.5 - Operate and configure network-based security appliances and services Firewalls and proxies (e.g., filtering methods, web application firewall (WAF), cloud access security broker (CASB)) Network intrusion detection/prevention systems Routers and switches Traffic-shaping devices (e.g., wide area network (WAN) optimization, load balancing) Network Access Control (NAC) Data Loss Prevention (DLP) Unified Threat Management (UTM) 6.6 - Secure wireless communications Technologies (e.g., cellular network, Wi-Fi, Bluetooth, Near-Field Communication (NFC)) Authentication and encryption protocols (e.g., Wi-Fi

Protected Access (WPA), Extensible Authentication Protocol (EAP), Wi-Fi Protected Access 2 (WPA2), Wi-Fi Protected Access 3 (WPA3)) 6.7 Secure and monitor Internet of Things (IoT) (e.g., configuration, network isolation, firmware updates, End of Life (EOL) management) 7.1 - Identify and analyze malicious code and activity Malware (e.g., rootkits, spyware, scareware, ransomware, trojans, virus, worms, trapdoors, backdoors, fileless, app/code/operatin3 system (OS)/mobile code vulnerabilities) Malware countermeasures (e.g., scanners, anti-malware, containment and remediation, software security) Types of malicious activity (e.g., insider threat, data theft, distributed denial of service (DDoS), botnet, zero-day exploits, web-based attacks, advanced persistent threat (APT)) Malicious activity countermeasures (e.g., user awareness/training, system hardening, patching, isolation, data loss prevention (DLP)) Social engineering methods (e.g., SPAM email, phishing/smishing/vishing, impersonation, scarcity, whaling) Behavior analytics (e.g., machine learning, Artificial Intelligence (AI), data analytics) 7.2 - Implement and operate endpoint device security Host-based intrusion prevention system (HIPS) Host-based intrusion detection system (HIDS) Host-based firewalls Application white listing Endpoint encryption (e.g., full disk encryption) Trusted Platform Module (TPM) (e.g., hardware security module management) Secure browsing (e.g., digital certificates) Endpoint detection and response (EDR) 7.3 - Administer and manage mobile devices Provisioning techniques (e.g., corporate owned, personally enabled (COPE), Bring Your Own Device (BYOD), Mobile Device Management (MDM)) Containerization Encryption Mobile application management 7.4 - Understand and configure cloud security Deployment models (e.g., public, private, hybrid, community) Service models (e.g., Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS)) Virtualization (e.g., hypervisor, Virtual Private Cloud (VPC)) Legal and regulatory concerns (e.g., privacy, surveillance, data ownership, jurisdiction, eDiscovery, shadow information technology (IT)) Data storage, processing, and transmission (e.g., archiving, backup, recovery, resilience) Third-party/Outsourcing requirements (e.g., service-level agreement (SLA), data portability/ privacy/destruction/auditing) Shared responsibility model 7.5 - Operate and maintain secure virtual environments Hypervisor (i.e., Type 1 (e.g., bare metal), Type 2 (e.g., software)) Virtual appliances Containers Continuity and resilience Storage management (e.g., data domain) Threats, attacks, and countermeasures (e.g., brute-force attack, virtual machine escape, threat hunting) Additional Examination Information Supplementary References Candidates are encouraged to supplement their education and experience by reviewing relevant resources that pertain to the CBK and identifying areas of study that may need additional attention. View the full list of supplementary references at www.isc2.org/certifications/References. Examination Policies and Procedures ISC2 recommends that SSCP candidates review exam policies and procedures prior to registering for the examination. Read the comprehensive breakdown of this important information at www.isc2.org/Register-for-Exam. A safe and secure cyber world The Center for Cyber Safety & EducationISC2 CareersCommunityBlog Frequently Asked QuestionsContact UsPolicies and Procedures ISC2 Authorized China AgencyISC2 Japan © Copyright 1996-2025. ISC2, Inc. All Rights Reserved. All contents of this site constitute the property of ISC2, Inc. and may not be copied, reproduced or distributed without prior written permission. ISC2, CISSP, SSCP, CCSP, CGRC, CSSLP, HCISPP, ISSAP, ISSEP, ISSMP, CC, and CBK are registered marks of ISC2, Inc. Sitemap SSCP Exam Outline Agree to ISC2 policies back to previous step CC: Certified in Cybersecurity (CC) ISC2 policies Admission Policy Plan to arrive at your test center at least 30 minutes before your exam start time. To check in for your appointment the following is required: Show two (2) valid, unexpired forms of personal ID (examples include: government issued ids, passports, etc.). Both must have your name (exactly as it appears in your exam registration) and signature, and one of the two must have your photo. For more information about acceptable IDs please visit: https://www.isc2.org/Exams/Exam-Day and look under What You Need to Bring to the Test Center tab for more information. oUnacceptable form of ID: Digital IDs (A digital ID is an electronic representation of personally identifying information that may be used to verify the identity of a person) For additional information regarding the Aadhaar ID, please visit Aadhaar ID Policy for Pearson VUE. Minors under 18 – Minor must be accompanied by a parent or guardian on the day of exam. oPlease refer for ID requirements for minors, https://www.isc2.org/exams/exam-day Provide your signature. Submit to a palm vein scan (unless expressly prohibited by law). Have your photo taken. Hats, scarves, and coats may not be worn for your photo. Additionally, you may not wear these items in the test room. Leave your personal belongings outside the testing room. You will have access to secure storage. As storage space is limited, please plan appropriately. Pearson VUE test centers do not assume responsibility for your personal belongings. Receive a short orientation from the Test Administrator (TA). After the orientation, the TA will escort you to a testing station. Sign and agree to the Non-Disclosure Agreement that will be presented at the beginning of your exam. Please take a moment to review the agreement now so that you are familiar with it when you sit for your exam. Where selected by your Test Sponsor, you agree that Pearson VUE will collect your palm vein pattern at the test center on the day of your exam and retain that information, to the extent permitted by law. Your palm vein scan will be used for the purposes of identification verification on the day of your test and on your future test days, detecting and preventing any fraud, and maintaining the security and integrity of the testing program. For more information on Pearson VUE's policy for use and retention of personal data including biometric data like palm vein scans, please see our Privacy and Cookies Policy. Your agreement to these Testing policies includes agreement to the Privacy and Cookies Policy. Reschedule Policy If you wish to reschedule your exam appointment, you must contact Pearson VUE. There is no fee for rescheduling the Certified in Cybersecurity (CC) exam. For all other certifications, there is a US$50 fee for exam appointment rescheduled. If you choose to go online to reschedule your appointment, you must do so at least 48 hours prior to your appointment. If you choose to call the Pearson customer support team to reschedule, you must do so at least 24 hours prior to your appointment. If you do not reschedule your exam appointment without proper advanced notice, as outlined above, it will result in a no-show, and you will forfeit your exam fee. If you used the ISC2 Candidate promo code, as part of the One Million Certified in Cybersecurity initiative, you will not be able to register again with that code. Once scheduled you have up to 365 days to sit for your exam. Failure to sit for your examination within 365 days will result in a no-show and forfeiture of all exam and rescheduling fees. Cancellation Policy If you wish to cancel your exam appointment, you must contact Pearson VUE. There is no fee for canceling the Certified in Cybersecurity (CC) exam. For all other certifications, there is a US$100 fee for exam appointment cancelations. If you choose to go online to cancel your appointment, you must do so at least 48 hours prior to your appointment. If you choose to call the Pearson customer support team to cancel, you must do so at least 24 hours prior to your appointment. If you do not cancel your exam appointment without proper advanced notice, as outlined above, it will result in a no-show, and will forfeit your exam fee. If you used the ISC2 Candidate promo code, as part of the One Million Certified in Cybersecurity initiative, you will not be able to register again with that code. Additional Information ISC2 Terms and Conditions ISC2 requires that all candidates for certification read and accept the terms and conditions set forth here: https://www.isc2.org/uploadedFiles/Certification_Programs/CBT-Examination-Agreement.pdf. Candidates that do not agree to the terms and conditions will not be permitted to sit for any ISC2 examination. Non-Disclosure Agreement (NDA) Failure to read or accept the ISC2 NDA agreement within the allotted five minutes will result in exam termination and forfeiture of exam appointment. Forfeiture of exam appointment also includes forfeiture of all exam fees. To take the examination at a later date you will be required to re-register for the exam and pay all applicable registration fees. Important Information on ISC2 Exams One of the benefits to candidates taking an examination via Computer-Based Testing is that most candidates receive their scores immediately upon completing their examination. In some cases, ISC2 must conduct periodic psychometric analyses prior to releasing exam results. For the small number of candidates affected by this process, it is expected that candidates will receive their results within 6 -8 weeks following the exam. ISC2 offers two types of computer-based exams – linear and adaptive – however neither exam type allows for candidates to skip an item, nor can items be returned to later during administration. Once an answer is confirmed it cannot be changed, reviewed, or revisited. Frequently asked questions (FAQs) and answers for common inquiries that can be found here: https://www.isc2.org/Frequently-Asked-Questions. Accommodations Policy ISC2 provides reasonable and appropriate accommodations for people who have a documented need for exam accommodations. Accommodations must be requested and approved by ISC2 prior to scheduling your examination. If you wish to request an accommodation, please visit https://www.isc2.org/Register-for-Exam and look under the Requesting Special Accommodations tab for information and instructions on how to request an accommodation. Test accommodations are individualized and considered on a case-by-case basis. Once an accommodation is approved, ISC2 will inform the Pearson VUE Accommodations team. Please allow up to three business days for Pearson VUE to receive this information. Then, contact Cart Collapsed, toggle side navigation to expand Edit my profile Tshingombe Tshingombe Tshitadi ISC2 ID: 1907033 Dashboard My Profile Sign out Almost there... back to previous step Confirm Order Details Description Details Price Exam CC: Certified in Cybersecurity (CC) Language: English Length: 120 minutes Appointment Friday, March 14, 2025 Start time: 8:00 AM Africa/Johannesburg - SAST Location Pearson Professional Centers-Johannesburg Pearson VUE 6th Floor Sandton City Office Tower Sandton City Shopping Centre 158 5th Street, SANDTON Johannesburg 2146 South Africa 199.00 Payment Details Exams for Name: Tshingombe Tshingombe Tshitadi ISC2 ID: 1907033 Order Total Subtotal: 199.00 Tax: 0.00 TOTAL DUE: USD 199.00 USD 199.00 Pearson VUE, so you can schedule your exam, contact information can be found at www.pearsonvue.com/isc2/contact. Accommodations are not a guarantee of improved performance or exam completion. Once an initial exam appointment is scheduled, there may be a US$50 fee to reschedule an exam with an approved accommodation. Agree to ISC2 policies Top of Form back to previous step Bottom of Form Top of Form CCSP: Certified Cloud Security Professional (CCSP) CGRC: Certified in Governance Risk and Compliance CISSP: Certified Information Systems Security Professional CSSLP: Certified Secure Software Lifecycle Professional ISSAP: Information Systems Security Architecture Professional ISSMP: Information Systems Security Management Professional SSCP: Systems Security Certified Practitioner Certification Exam Outline Effective Date: November 15, 20222 ISSMP Certification Exam Outline About CISSP-ISSMP The Information Systems Security Management Professional (ISSMP) is a CISSP who specializes in establishing, presenting and governing information security programs and demonstrates management and leadership skills. CISSP-ISSMPs direct the alignment of security programs with the organization's mission, goals and strategies in order to meet enterprise financial and operational requirements in support of its desired risk position. The broad spectrum of topics included in the CISSP-ISSMP Common Body of Knowledge (CBK®) ensure its relevancy across all disciplines in the field of information security management. Successful candidates are competent in the following six domains: • Leadership and Business Management • Systems Lifecycle Management • Risk Management • Threat Intelligence and Incident Management • Contingency Management • Law, Ethics and Security Compliance Management Experience Requirements Candidates must be a CISSP in good standing and have two years cumulative paid work experience in one or more of the six domains of the CISSP-ISSMP CBK. You can learn more about CISSP-ISSMP experience requirements and how to account for part-time work and internships at www.isc2.org/Certifications/CISSP-Concentrations#steps-to-certification. Accreditation CISSP-ISSMP is in compliance with the stringent requirements of ANSI/ISO/IEC Standard 17024. Job Task Analysis (JTA) (ISC)² has an obligation to its membership to maintain the relevancy of the CISSP-ISSMP. Conducted at regular intervals, the Job Task Analysis (JTA) is a methodical and critical process of determining the tasks that are performed by security professionals who are engaged in the profession defined by the CISSP-ISSMP. The results of the JTA are used to update the examination. This process ensures that candidates are tested on the topic areas relevant to the roles and responsibilities of today's practicing information security professionals.3 ISSMP Certification Exam Outline CISSP-ISSMP Examination Information CISSP-ISSMP Examination Weights Length of exam Number of items Item format Passing grade Exam availability Testing center 3 hours 125 Multiple choice 700 out of 1000 points English Pearson VUE Testing Center Domains Weight 1. Leadership and Business Management 20% 2. Systems Lifecycle Management 18% 3. Risk Management 19% 4. Threat Intelligence and Incident Management 17% 5. Contingency Management 15% 6. Law, Ethics and Security Compliance Management 11% Total: 100%4 ISSMP Certification Exam Outline Domain 1: Leadership and Business Management 1.1 Establish security's role in organizational culture, vision and mission » Define information security program vision and mission » Align security with organizational goals, objectives and values » Define security's relationship to the overall business processes » Define the relationship between organizational culture and security 1.2 Align security program with organizational governance » Identify and navigate organizational governance structure » Validate roles of key stakeholders » Validate sources and boundaries of authorization » Advocate and obtain organizational support for security initiatives 1.3 Define and implement information security strategies » Identify security requirements from business initiatives » Evaluate capacity and capability to implement security strategies » Manage implementation of security strategies » Review and maintain security strategies » Prescribe security architecture and engineering theories, concepts and methods 1.4 Define and maintain security policy framework Determine applicable external standards » Determine applicable external standards » Determine data classification and protection requirements » Establish internal policies » Advocate and obtain organizational support for policies » Develop procedures, standards, guidelines and baselines » Ensure periodic review of security policy framework5 ISSMP Certification Exam Outline » Define roles and responsibilities » Determine and manage team accountability » Build cross-functional relationships » Resolve conflicts between security and other stakeholders » Identify communication bottlenecks and barriers » Integrate security controls into human resources processes » Evaluate service management agreements (e.g., risk, financial) » Govern managed services (e.g., infrastructure, cloud services) » Manage impact of organizational change (e.g., mergers and acquisitions, outsourcing) » Ensure that appropriate regulatory compliance statements and requirements are included in contractual agreements » Monitor and enforce compliance with contractual agreements 1.5 Manage security requirements in contracts and agreements 1.6 Manage security awareness and training programs » Promote security programs to key stakeholders » Identify needs and implement training programs by target segment » Monitor and report on effectiveness of security awareness and training programs 1.7 Define, measure and report security metrics » Identify Key Performance Indicators (KPI) » Associate Key Performance Indicators (KPI) to the risk posture of the organization » Use metrics to drive security program development and operations 1.8 Prepare, obtain and administer security budget » Prepare and secure annual budget » Adjust budget based on evolving risks and threat landscape » Manage and report financial responsibilities 1.9 Manage security programs 1.10 Apply product development and project management principles » Incorporate security into project lifecycle » Identify and apply appropriate project management methodology » Analyze project time, scope and cost relationship6 ISSMP Certification Exam Outline 2.1 Manage integration of security into Systems Development Life Cycle (SDLC) » Integrate information security gates (decision points) and requirements into lifecycle » Implement security controls into system lifecycle » Oversee security configuration management (CM) processes 2.2 Integrate new business initiatives and emerging technologies into the security architecture » Integrate security into new business initiatives and emerging technologies » Address impact of new business initiatives on security posture 2.3 Define and oversee comprehensive vulnerability management programs (e.g., vulnerability scanning, penetration testing, threat analysis) » Identify, classify and prioritize assets, systems and services based on criticality to business » Prioritize threats and vulnerabilities » Manage security testing » Manage mitigation and/or remediation of vulnerabilities based on risk 2.4 Manage security aspects of change control » Integrate security requirements with change control process » Identify and coordinate with the stakeholders » Manage documentation and tracking » Ensure policy compliance (e.g., continuous monitoring) Domain 2: Systems Lifecycle Management 7 ISSMP Certification Exam Outline Domain 3: Risk Management 3.1 Develop and manage a risk management program » Identify risk management program objectives » Communicate and agree on risk management objectives with risk owners and other stakeholders » Determine scope of organizational risk program » Identify organizational security risk tolerance/appetite » Obtain and verify organizational asset inventory » Analyze organizational risks » Determine countermeasures, compensating and mitigating controls » Perform cost-benefit analysis (CBA) of risk treatment options 3.2 Conduct risk assessments » Identify risk factors 3.3 Manage security risks within the supply chain (e.g., supplier, vendor, third-party risk) » Identify supply chain security risk requirements » Integrate supply chain security risks into organizational risk management » Validate security risk control within the supply chain » Monitor and review the supply chain security risks8 ISSMP Certification Exam Outline 4.1 Establish and maintain threat intelligence program » Aggregate threat data from multiple threat intelligence sources » Conduct baseline analysis of network traffic, data and user behavior » Detect and analyze anomalous behavior patterns for potential concerns » Conduct threat modeling » Identify and categorize an attack » Correlate related security event and threat data » Create actionable alerting to appropriate resources 4.2 Establish and maintain incident handling and investigation program » Develop program documentation » Establish incident response case management process » Establish incident response team » Apply incident management methodologies » Establish and maintain incident handling process » Establish and maintain investigation process » Quantify and report financial and operational impact of incidents and investigations to stakeholders » Conduct root cause analysis (RCA) Domain 4: Threat Intelligence and Incident Management 9 ISSMP Certification Exam Outline 5.1 Facilitate development of contingency plans » Identify and analyze factors related to the Continuity of Operations Plan (COOP) » Identify and analyze factors related to the business continuity plan (BCP) (e.g., time, resources, verification) » Identify and analyze factors related to the disaster recovery plan (DRP) (e.g., time, resources, verification) » Coordinate contingency management plans with key stakeholders » Define internal and external crisis communications plans » Define and communicate contingency roles and responsibilities » Identify and analyze contingency impact on business processes and priorities » Manage third-party contingency dependencies » Prepare security management succession plan 5.2 Develop recovery strategies » Identify and analyze alternatives » Recommend and coordinate recovery strategies » Assign recovery roles and responsibilities 5.3 Maintain contingency plan, Continuity of Operations Plan (COOP), business continuity plan (BCP) and disaster recovery plan (DRP) » Plan testing, evaluation and modification » Determine survivability and resiliency capabilities » Manage plan update process 5.4 Manage disaster response and recovery process » Declare disaster » Implement plan » Restore normal operations » Gather lessons learned » Update plan based on lessons learned Domain 5: Contingency Management 10 ISSMP Certification Exam Outline 10 6.1 Identify the impact of laws and regulations that relate to information security 6.2 Adhere to the (ISC) 2 Code of Ethics as related to management issues 6.3 Validate compliance in accordance with applicable laws, regulations and industry best practices 6.4 Coordinate with auditors and regulators in support of the internal and external audit processes 6.5 Document and manage compliance exceptions » Identify and document compensating controls and workarounds » Report and obtain authorized approval of risk waiver Domain 6: Law, Ethics and Security Compliance Management » Identify applicable privacy laws » Identify legal jurisdictions the organization and users operate within (e.g., trans-border data flow) » Identify export laws » Identify intellectual property (IP) laws » Identify applicable industry regulations » Identify and advise on non-compliance risks » Inform and advise senior management » Evaluate and select compliance framework(s) » Implement the compliance framework(s) » Define and monitor compliance metrics » Plan » Schedule » Coordinate audit activities » Evaluate and validate findings » Formulate response » Validate implemented mitigation and remediation actions11 ISSMP Certification Exam Outline Additional Examination Information Supplementary References Candidates are encouraged to supplement their education and experience by reviewing relevant resources that pertain to the CBK and identifying areas of study that may need additional attention. View the full list of supplementary references at www.isc2.org/certifications/References. Examination Policies and Procedures (ISC)2 recommends that CISSP-ISSMP candidates review exam policies and procedures prior to registering for the examination. Read the comprehensive breakdown of this important information at www.isc2.org/Exams/Before-Your-Exam. Legal Info For any questions related to (ISC) 2 's legal policies, please contact the (ISC)2 Legal Department at legal@isc2.org. Any Questions? (ISC)2 Americas Tel: +1.866.331.ISC2 (4722) Email: info@isc2.org (ISC)2 Asia-Pacific Tel: +(852) 28506951 Email: isc2asia@isc2.org (ISC)2 EMEA Tel: +44 (0)203 300 1625 Email: info-emea@isc2.org 11 v222Certification Exam Outline Effective Date: November 13, 20202 ISSEP Certification Exam Outline About CISSP-ISSEP The Information Systems Security Engineering Professional (ISSEP) is a CISSP who specializes in the practical application of systems engineering principles and processes to develop secure systems. An ISSEP analyzes organizational needs, defines security requirements, designs security architectures, develops secure designs, implements system security, and supports system security assessment and authorization for government and industry. The broad spectrum of topics included in the ISSEP Common Body of Knowledge (CBK®) ensure its relevancy across all disciplines in the field of security engineering. Successful candidates are competent in the following five domains: • Systems Security Engineering Foundations • Risk Management • Security Planning and Design • Systems Implementation, Verification and Validation • Secure Operations, Change Management and Disposal Experience Requirements Candidates must be a CISSP in good standing and have two years cumulative paid work experience in one or more of the five domains of the CISSP-ISSEP CBK. You can learn more about CISSP-ISSEP experience requirements and how to account for part-time work and internships at www.isc2.org/Certifications/CISSP-ISSEP/experience-requirements. Accreditation CISSP-ISSEP is in compliance with the stringent requirements of ANSI/ISO/IEC Standard 17024. Job Task Analysis (JTA) (ISC)² has an obligation to its membership to maintain the relevancy of the ISSEP. Conducted at regular intervals, the Job Task Analysis (JTA) is a methodical and critical process of determining the tasks that are performed by security professionals who are engaged in the profession defined by the ISSEP. The results of the JTA are used to update the examination. This process ensures that candidates are tested on the topic areas relevant to the roles and responsibilities of today's practicing information security professionals.3 ISSEP Certification Exam Outline CISSP-ISSEP Examination Information CISSP-ISSEP Examination Weights Length of exam Number of items Item format Passing grade Exam availability Testing center 3 hours 125 Multiple choice 700 out of 1000 points English Pearson VUE Testing Center Domains Weight 1. Systems Security Engineering Foundations 25% 2. Risk Management 14% 3. Security Planning and Design 30% 4. Systems Implementation, Verification and Validation 14% 5. Secure Operations, Change Management and Disposal 17% Total: 100%4 ISSEP Certification Exam Outline Domain 1: Systems Security Engineering Foundations 1.1 Apply systems security engineering fundamentals 1.2 Execute systems security engineering processes 1.3 Integrate with applicable system development methodology 1.4 Perform technical management 1.5 Participate in the acquisition process 1.6 Design Trusted Systems and Networks (TSN) » Understand systems security engineering trust concepts and hierarchies » Identify the relationships between systems and security engineering processes » Apply structural security design principles » Integrate security tasks and activities » Verify security requirements throughout the process » Integrate software assurance methods » Perform project planning processes » Perform project assessment and control processes » Perform decision management processes » Perform risk management processes » Perform configuration management processes » Perform information management processes » Perform measurement processes » Perform Quality Assurance (QA) processes » Identify opportunities for security process automation » Identify organizational security authority » Identify system security policy elements » Integrate design concepts (e.g., open, proprietary, modular) » Prepare security requirements for acquisitions » Participate in selection process » Participate in Supply Chain Risk Management (SCRM) » Participate in the development and review of contractual documentation5 ISSEP Certification Exam Outline Domain 2: Risk Management 2.1 Apply security risk management principles 2.2 Address risk to system 2.3 Manage risk to operations » Establish risk context » Identify system security risks » Perform risk analysis » Perform risk evaluation » Recommend risk treatment options » Document risk findings and decisions » Determine stakeholder risk tolerance » Identify remediation needs and other system changes » Determine risk treatment options » Assess proposed risk treatment options » Recommend risk treatment options » Align security risk management with Enterprise Risk Management (ERM) » Integrate risk management throughout the lifecycle6 ISSEP Certification Exam Outline 3.1 Analyze organizational and operational environment 3.2 Apply system security principles 3.3 Develop system requirements 3.4 Create system security architecture and design Domain 3: Security Planning and Design » Capture stakeholder requirements » Identify relevant constraints and assumptions » Assess and document threats » Determine system protection needs » Develop Security Test Plans (STP) » Incorporate resiliency methods to address threats » Apply defense-in-depth concepts » Identify fail-safe defaults » Reduce Single Points of Failure (SPOF) » Incorporate least privilege concept » Understand economy of mechanism » Understand Separation of Duties (SoD) concept » Develop system security context » Identify functions within the system and security Concept of Operations (CONOPS) » Document system security requirements baseline » Analyze system security requirements » Develop functional analysis and allocation » Maintain traceability between specified design and system requirements » Develop system security design components » Perform trade-off studies » Assess protection effectiveness7 ISSEP Certification Exam Outline Domain 4: Systems Implementation, Verification and Validation 4.1 Implement, integrate and deploy security solutions 4.2 Verify and validate security solutions » Perform system security implementation and integration » Perform system security deployment activities » Perform system security verification » Perform security validation to demonstrate security controls meet stakeholder security requirements8 ISSEP Certification Exam Outline Domain 5: Secure Operations, Change Management and Disposal 5.1 Develop secure operations strategy 5.2 Participate in secure operations 5.3 Participate in change management 5.4 Participate in the disposal process » Specify requirements for personnel conducting operations » Contribute to the continuous communication with stakeholders for security relevant aspects of the system » Develop continuous monitoring solutions and processes » Support the Incident Response (IR) process » Develop secure maintenance strategy » Participate in change reviews » Determine change impact » Perform verification and validation of changes » Update risk assessment documentation » Identify disposal security requirements » Develop secure disposal strategy » Develop decommissioning and disposal procedures » Audit results of the decommissioning and disposal process9 ISSEP Certification Exam Outline Additional Examination Information Supplementary References Candidates are encouraged to supplement their education and experience by reviewing relevant resources that pertain to the CBK and identifying areas of study that may need additional attention. View the full list of supplementary references at www.isc2.org/certifications/References. Examination Policies and Procedures (ISC)² recommends that ISSEP candidates review exam policies and procedures prior to registering for the examination. Read the comprehensive breakdown of this important information at www.isc2.org/Register-for-Exam. Legal Info For any questions related to (ISC)²'s legal policies, please contact the (ISC)2 Legal Department at legal@isc2.org. Any Questions? (ISC)² Americas Tel: +1-866-331-ISC2(4722) Email: membersupport@isc2.org (ISC)² Asia Pacific Tel: +852-2850-6951 Email: membersupportapac@isc2.org (ISC)² EMEA Tel: +44-203-960-7800 Email: membersupportemea@isc2.org 9 Attachments Rate this Details Lenovo and Intel are Driving AI Innovation at the Edge Flynn Maloy, Chief Marketing Officer of Lenovo ISG Jan 23 2025| 0 mins Lenovo and Intel's long-standing partnership is transforming industries by bringing cutting-edge AI solutions to the edge and beyond. From PCs to data centers, our collaboration has consistently pushed technological boundaries. The strength of Lenovo's ThinkEdge portfolio is enabling AI-driven applications in manufacturing sites, retail stores, schools, and more. Join @Flynn Maloy, Chief Marketing Officer of Lenovo ISG, as he details how Lenovo and Intel® are leading the way in AI innovation: - Comprehensive solutions for diverse industries: From computer vision in manufacturing to advanced AI in education and retail, Lenovo and Intel's joint solutions empower a variety of applications. - Next-gen AI with CPUs: Not every AI workload requires massive GPUs. Intel's CPUs are driving the next wave of edge AI, particularly in inferencing and delivering efficient and accessible AI solutions. - Scalable and powerful edge portfolio: Lenovo's edge clients and servers, powered by Intel, are designed to meet the demands of modern businesses, offering flexibility and performance across workloads. - A partnership that drives innovation: With a shared vision for the future of AI, Lenovo and Intel continue to push the boundaries of what's possible for our customers. Together, Lenovo and Intel are leading the charge in making AI more accessible, scalable, and impactful for businesses worldwide. State of Cloud 2025: Navigating EMEA's Cloud Revolution John Bradshaw, Director of Cloud Computing Technology and Strategy, EMEA, Akamai & Bryan Glick, Editor in Chief, Computer Weekly Feb 27 2025| 18 mins Boris Cipot, Senior Security Engineer Sep 05 2024| 30 mins Python is a fast, platform-agnostic, and easy-to-learn programming language that is suited for beginners and experienced developers alike. Ever since its first release in 1991, Python has had a constant presence in the computer world and has become a go-to language thanks to its easy-to-understand code and versatility. Today, Python can boast a wide array of libraries and frameworks, and they are the cornerstone of fast and easy Python programming—the so-called Pythonic way of development. But like all programming languages, Python is not immune to security threats. Secure coding best practices must be adopted to avoid risks from attackers. In this webinar, we'll explore Python security best practices that should employed when building secure application. One-Stop DevOps: Simplifying Toolchains with GitLab and Google Cloud Nate Avery, Outbound Product Manager - Google | Jackie Porter, Director of Product - Gitlab | Torsten Volk, Principal Analyst - ESG Dec 04 2024| 28 mins Seamless Edge Deployment and Management with Lenovo and Intel Blake Kerrigan, Senior Director, ThinkEdge Business Group Jan 23 2025| 1 mins Sort by Career Opportunity Senior Applied Scientist – Copilot Team Posted: March 3, 2025 Location: Beijing, China Research Area(s): Artificial intelligence We are inviting you to join the Copilot Team, where we are redefining the future of AI-powered experiences. The Copilot Team is at the forefront of innovation, building intelligent solutions that empower users across devices… Career Opportunity Senior Applied AI Engineer – Microsoft Security AI Research team Posted: March 3, 2025 Location: Remote (within US) Research Area(s): Artificial intelligence, Security, privacy, and cryptography Join the vanguard of cybersecurity innovation with the Microsoft Security AI Research team. We are on the lookout for an Applied Scientist to spearhead the research and development of functional autonomous agents for security scenarios…. Career Opportunity Data Scientist II – Microsoft Security Posted: March 1, 2025 Location: Remote (within US); United States Research Area(s): Artificial intelligence, Data platforms and analytics, Human-computer interaction, Security, privacy, and cryptography The AI Personalization, Feedback, and Analytics team ensures that Security Copilot, Microsoft's GenAI platform, delivers adaptive and intelligent experiences by leveraging feedback loops, analytics, and personalization techniques. We are seeking a Data Scientist to help… Career Opportunity Senior Applied Scientist – Power Apps Posted: March 1, 2025 Location: Redmond, WA, US; Remote (within US) Research Area(s): Algorithms, Artificial intelligence, Data platforms and analytics The Power Apps team at Microsoft is looking to hire a Senior Applied Scientist. As a team, we are very customer focused and driven by curiosity, creativity, teamwork, agility, accountability and desire to learn everyday.… Career Opportunity Applied Scientist II – Power Apps Posted: March 1, 2025 Location: Redmond, WA, US; Remote (within US) Research Area(s): Algorithms, Artificial intelligence, Data platforms and analytics, Programming languages and software engineering The Power Apps team at Microsoft is looking to hire an Applied Scientist II. As a team, we are very customer focused and driven by curiosity, creativity, team work, agility, accountability and desire to learn everyday. If… Career Opportunity Principal Applied Scientist – Advanced Autonomy and Applied Robotics Posted: March 1, 2025 Location: Redmond, WA, US Research Area(s): Artificial intelligence, Hardware and devices, Human-computer interaction, Technology for emerging markets Within Microsoft's Strategic Missions and Technologies (SMT) division, the Advanced Autonomy and Applied Robotics team is seeking a Principal Applied Scientist.The role involves building the future platform for human-robot-agent teaming. This individual will leverage cutting-edge AI and robotics technologies… Career Opportunity Senior Applied Scientist – Advanced Autonomy and Applied Robotics Posted: March 1, 2025 Location: Redmond, WA, US Research Area(s): Artificial intelligence, Hardware and devices, Human-computer interaction, Technology for emerging markets Within Microsoft's Strategic Missions and Technologies (SMT) division, the Advanced Autonomy and Applied Robotics team is seeking a Senior Applied Scientist. The role involves building the future platform for human-robot-agent teaming. This individual will leverage… Career Opportunity Principal Researcher – Generative AI – Microsoft Research AI Frontiers Posted: March 1, 2025 Location: New York, NY, US; Redmond, WA, US Research Area(s): Artificial intelligence We are seeking a Principal Researcher to join our team and lead efforts on the advancement of Generative AI and Large Language Models (LLMs) technologies. As a Principal Researcher, you will play a crucial role in leading,… Career Opportunity Senior Applied Scientist Posted: March 1, 2025 Location: Cairo, Egypt Research Area(s): Artificial intelligence In shaping the future of monetization for personalized AI assistants and pioneering innovation in the advertiser agentic space, as a Senior Applied Scientist, you will collaborate with engineers, data scientists, and product managers to develop… Career Opportunity Principal Data Scientist – Real-Time Intelligence team Posted: February 28, 2025 Location: Redmond, WA, US Research Area(s): Artificial intelligence, Data platforms and analytics, Systems and networking Microsoft Fabric's Real-Time Intelligence team is leading the transformation of real-time analytics in the world of data. We are hiring a Principal Data Scientist to tackle challenges in both open-source and proprietary technologies related to engineering Inbox tshingombe fiston Mon, Mar 3, 3:19 PM (18 hours ago) to me namics 365 Community / My Profile CU03031227-0 Stats 0 Comments 0 Posts 1 Likes 0 Questions My activity Achievements Personal information Achievements Notifications Notification settings Quick responses Personal information Email tshingombefiston@gmail.com Confirmation Registration details Name tshingombe tshitadi Status Registered Registration ID 102231646 Quick Links Go to the Microsoft Research Forum Website Registration support Cancel registration Please note: event emails will be sent to the email address you provided during registration. If you are not receiving event communications, please check your 'junk', 'spam', or 'clutter' folders to confirm your email settings have not redirected the emails. In addition, please add msresearchforum@eventcore.com to your 'safe sender' list to ensure you receive future communications for this event. Microsoft is committed to your privacy. If you have questions surrounding how your registration is affected by the General Data Protection Regulation (GDPR), then please visit Privacy Management for more information. Share the news you've registered! Compare Microsoft 365 with Office Best value for 2 to 6 people Microsoft 365 Family Subscription R1 999,00/year Buy now Or buy at R199,00/month Try free for 1 month Microsoft 365 Personal Subscription R1 599,00/year Buy now Or buy at R159,00/month Office Home 2024 One-time purchase for PC or Mac R2 299,00 Buy now Microsoft 365 Family Microsoft 365 Personal Office Home 2024 Number of users 1 to 6 people 1 person One PC or Mac Number of accounts 1 to 6 1 One PC or Mac Cloud storage Up to 6 TB (1 TB per person) 1 TB Multiple devices and platforms Included Included Word, Excel, PowerPoint Included Included Included OneNote Included Included Included Outlook Included Included Ongoing technical support Included Included Microsoft Defender Included Included Microsoft Editor Included Included Clipchamp Included Included Microsoft Teams Included Included Access (PC only) Included Included Microsoft Forms Included Included Learn more Learn more Learn more Office Home & Business 2024 One-time purchase for one PC or Mac Classic 2024 desktop versions of Word, Excel, PowerPoint, Outlook and OneNote Access to support resources Buy now Learn more Frequently asked questions | 4 is sold as a one-time purchase, which means you pay a single, up-front cost to get Office apps for one computer. One-time purchases are available for both PCs and Macs. However, there are no upgrade options, which means if you plan to upgrade to the next major release, you'll have to buy it at full price. Microsoft 365 Personal and Microsoft 365 Family are subscriptions that include powerful productivity apps and creativity tools with AI-powered features. In addition to premium desktop versions of popular Microsoft 365 apps like Word, PowerPoint, Excel and Outlook, you also get spacious cloud storage and cloud-connected features that let you collaborate on files in real time. With a subscription, you'll always have the latest features, fixes and security updates along with ongoing tech support at no extra cost. You can choose to pay for your subscription on a monthly or yearly basis, and use your apps on multiple PCs, Macs, tablets and phones. Additionally, the Microsoft 365 Family plan lets you share your subscription with up to five more people. Everyone gets their own apps and storage. (AI features only available to subscription owner and cannot be shared; AI usage limits apply; minimum age limits may apply to subscription activation and use of AI features. Learn more.) Microsoft 365 is compatible with PC, Mac, Android and iOS. See system requirements for compatible versions of your devices, and for other feature requirements. No. Microsoft 365's applications are tailored for each platform and each operating system. The applications available for Mac users and the specific features included may be different from those available for PC users. With Microsoft 365, you can be flexible. With your account, you are not limited to exclusively Mac or exclusively PC, so you can transition across devices. Yes. Documents that you have created belong fully to you. You can choose to store them online on OneDrive or locally on your PC or Mac. Internet access is required to install and activate all the latest releases of apps and services included in all Microsoft 365 subscription plans. Note that if you are an existing subscriber, you do not need to reinstall or purchase another subscription. For Microsoft 365 plans, internet access is also needed to manage your subscription account, for example to install Office apps on other PCs or to change billing options. Internet access is also required to access documents stored on OneDrive, unless you install the OneDrive desktop app. You should also connect to the internet regularly to keep your version of Microsoft 365 up to date and to benefit from automatic upgrades. If you do not connect to the internet at least every 31 days, your apps will go into reduced functionality mode, which means that you can view or print your documents but cannot edit the documents or create new ones. To reactivate your apps, simply reconnect to the internet. You do not need to be connected to the internet to use the Office apps, such as Word, Excel and PowerPoint, because the apps are fully installed on your computer. Your Microsoft account is the combination of an email address and password that you use to sign in to services like OneDrive, Xbox LIVE and Outlook.com. If you use any of these services, you already have a Microsoft account that you can use, or you can create a new account. Learn more about Microsoft accounts. As part of signing up for a trial or purchasing Microsoft 365, you will be prompted to sign in with a Microsoft account. You must be signed in with this account to install and manage your Microsoft 365 subscription, or to use some subscription benefits, including cloud storage. You can share Microsoft 365 Family with five other people, for a total of six users. Microsoft 365 Personal can be used by one person. If you have an active Microsoft 365 Family subscription, you can share it with up to five other people. Each person you share your subscription with can install Microsoft 365 on all their devices and sign in to five devices at the same time. To add someone to your subscription, sign in to your Microsoft account and follow the on-screen instructions to add a user. Each person you add will receive an email with the steps they need to follow. Once they have accepted and completed the steps, their information, including the installs they are using, will appear on their My Account page. You can stop sharing your subscription with someone or remove a device they are using by logging into your Microsoft account. Visit learn more about free apps. Microsoft Defender is a cross-device security app that helps individuals and families protect their data and devices by continuously scanning the web for threats to your identity and personal data (US only). Defender also helps you stay safer online with malware protection, real-time security notifications and security tips. Download the Microsoft Defender app. Microsoft Defender is a new cross-device app that helps people and families stay safer online. Microsoft Defender adds new features and a simplified user interface. Microsoft Defender also brings valuable device protection to iOS, Android, Windows and Mac, with malware protection, web protection, real-time security notifications and security tips. Microsoft Defender is available in the Apple, Google and Microsoft app stores and requires a Microsoft 365 Personal or Family subscription to use. Windows Security, formerly known as Windows Defender Security Centre, is built-in security on Windows PCs to protect your device and data. Windows Security is pre-installed and automatically enabled. Windows Security includes Microsoft Defender Antivirus software that protects your Windows device and data against viruses, ransomware, trojans and other malware unless non-Microsoft antivirus software is active. A free in-browser video editing platform designed to make video creation accessible for everyone. AI features included in Microsoft 365 Family plans are only available to the subscription owner and cannot be shared with others. To use Copilot in Word, Excel, PowerPoint, OneNote and Outlook, make sure you have the latest version of Microsoft 365 installed. If you're signed in, have the latest updates installed, and still don't see Copilot, please restart your Microsoft 365 apps. Learn more about why I am not seeing Copilot in my apps. Microsoft 365 supports Arabic, Chinese Simplified, Chinese Traditional, Czech, Danish, Dutch, English, Finnish, French, German, Hebrew, Hungarian, Italian, Japanese, Korean, Norwegian, Polish, Portuguese, Russian, Spanish, Swedish, Thai and Turkish. Some Designer features, like inline editing capabilities, are available only in English. We plan to add more languages soon. You can also learn more about Copilot supported languages here: Copilot for Microsoft 365 supported languages – Microsoft Support. Visit our Copilot help & learning site to start using Copilot today. Microsoft Designer is a graphic design and image editing app powered by AI. Create eye-catching images with your words, craft next-level designs that pop and even edit photos like an expert. Designer is integrated across your favourite Microsoft apps like Word and PowerPoint to help you create when and where you need it. Beyond the Microsoft Designer web and mobile app, certain Designer features are integrated across some of your favourite Microsoft apps like Word and PowerPoint, helping spark creativity where and when you need it. For Windows users, Designer is also integrated into Microsoft Photos. Usage limits apply to AI-powered features, including Copilot and Designer. Your Microsoft 365 Personal or Family subscription unlocks AI credits to experience and engage with Copilot across Microsoft 365 apps and beyond. Learn more about credits. Microsoft 365 Business Basic, Business Standard and Business Premium are tailored for businesses, offering professional email with a custom domain, admin controls for managing access and devices and scalability to add additional users as your business grows. They include advanced security features like Exchange Online Protection to guard against phishing and malware, with Business Premium adding Microsoft Defender for Business for ransomware protection and advanced threat management. Plus, you can access professional collaboration tools like Microsoft Teams with meeting recordings, transcription and team workspaces, while business apps such as Microsoft Bookings can simplify meeting and appointment scheduling. Additionally, Microsoft 365 Copilot, an AI-powered assistant for work, is available as an add-on to boost productivity and creativit Lenovo is simplifying edge computing deployment and management with Lenovo Open Cloud Automation (LOC-A), a powerful tool that provides our customers with the efficiency and ease they've come to expect from data center management – now applied to distributed edge environments. Join @blake Kerrigan, Senior Director, ThinkEdge Business Group, as he details how Lenovo and Intel® are enabling businesses to deploy and scale edge solutions faster, while unlocking the full potential of AI and edge computing with: - Unified management: LOC-A offers a single-pane-of-glass experience, allowing businesses to manage thousands of systems across distributed locations seamlessly. - Enhanced capabilities with Intel: The integration of Intel's Tiber™ Edge Platform brings advanced tools like OpenVINO™ into edge environments, optimizing AI workloads for greater efficiency. - Faster time-to-value: Together, Lenovo and Intel ensure that customers can deploy solutions quickly and get results faster. - Scalable solutions: Whether managing one system or thousands, businesses can scale confidently with tools designed for distributed edge environments. With Lenovo and Intel, edge computing has never been more accessible, scalable, and powerful.Enterprise Strategy Group (ESG) data shows that 65% of developers' time is consumed by overhead tasks related to context switching, pipeline integration, compliance, monitoring and logging, managing secrets, and so on. This avalanche of tasks—not to mention the dozen or more tools involved to execute them—slows down productivity, increases the risk of security vulnerabilities, and complicates automated deployment in the DevSecOps pipeline. In this webinar, ESG Principal Analyst Torsten Volk joins Nate Avery, Google's Outbound Product Manager, and Jackie Porter, GitLab's Product Marketing Director, to explain how to deliver code faster, enhance developer productivity, and improve security across the DevOps tool chain and into the cloud. Save your seat to discover how to resolve pressing DevSecOps pain points like tool sprawl, and how GitLab and Google's integration greatly assists with this process, reducing manual developer tasks and unifying security automation.Watch our on-demand panel discussion with Bryan Glick, Editor in Chief at Computer Weekly, as we explore the key trends shaping cloud innovation in 2025. Discover how AI integration, edge-native applications, and distributed cloud are transforming strategies across EMEA. Gain actionable insights on application modernisation, cost optimisation, and real-world success stories to help your organisation thrive. Key Takeaways: - How regional challenges are driving cloud adoption - Distributed cloud's role in AI and performance optimisation - Strategies for modernising applications and cutting costs Watch now on-demand! Bottom of Form Course Microsoft Azure AI Fundamentals Course AI-900T00-A: Microsoft Azure AI Fundamentals At a glance Level Beginner Product Azure Role AI Engineer Languages English Arabic Chinese (Simplified) Chinese (Traditional) French German Indonesian Italian Japanese Korean Portuguese (Brazil) Russian Spanish Course Duration 1 day Related certifications Microsoft Certified: Azure AI Fundamentals Overview This course introduces fundamentals concepts related to artificial intelligence (AI), and the services in Microsoft Azure that can be used to create AI solutions. The course is not designed to teach students to become professional data scientists or software developers, but rather to build awareness of common AI workloads and the ability to identify Azure services to support them. The course is designed as a blended learning experience that combines instructor-led training with online materials on the Microsoft Learn platform (https://azure.com/learn). The hands-on exercises in the course are based on Learn modules, and students are encouraged to use the content on Learn as reference materials to reinforce what they learn in the class and to explore topics in more depth. Audience Profile The Azure AI Fundamentals course is designed for anyone interested in learning about the types of solution artificial intelligence (AI) makes possible, and the services on Microsoft Azure that you can use to create them. You don't need to have any experience of using Microsoft Azure before taking this course, but a basic level of familiarity with computer technology and the Internet is assumed. Some of the concepts covered in the course require a basic understanding of mathematics, such as the ability to interpret charts. The course includes hands-on activities that involve working with data and running code, so a knowledge of fundamental programming principles will be helpful. Course Syllabus You can prepare in instructor-led training or self-paced study Learning Path Microsoft Azure AI Fundamentals: AI Overview o3 Modules oBeginner oAI Engineer oAzure AI Bot Service 70% Learning Path Microsoft Azure AI Fundamentals: Computer Vision 3 Modules Beginner AI Engineer Azure 97% Learning Path Microsoft Azure AI Fundamentals: Natural Language Processing 5 Modules Beginner AI Engineer Azure Portal 95% Learning Path Microsoft Azure AI Fundamentals: Document Intelligence and Knowledge Mining 2 Modules Beginner AI Engineer Azure Completed Learning Path Microsoft Azure AI Fundamentals: Generative AI 1 of 4 modules completed Beginner AI Engineer Azure OpenAI Service 20% Search for a training provider Course Microsoft Azure AI Fundamentals Course AI-900T00-A: Microsoft Azure AI Fundamentals At a glance Level Beginner Product Azure Role AI Engineer Languages English Arabic Chinese (Simplified) Chinese (Traditional) French German Indonesian Italian Japanese Korean Portuguese (Brazil) Russian Spanish Course Duration 1 day Related certifications Microsoft Certified: Azure AI Fundamentals Overview This course introduces fundamentals concepts related to artificial intelligence (AI), and the services in Microsoft Azure that can be used to create AI solutions. The course is not designed to teach students to become professional data scientists or software developers, but rather to build awareness of common AI workloads and the ability to identify Azure services to support them. The course is designed as a blended learning experience that combines instructor-led training with online materials on the Microsoft Learn platform (https://azure.com/learn). The hands-on exercises in the course are based on Learn modules, and students are encouraged to use the content on Learn as reference materials to reinforce what they learn in the class and to explore topics in more depth. Audience Profile The Azure AI Fundamentals course is designed for anyone interested in learning about the types of solution artificial intelligence (AI) makes possible, and the services on Microsoft Azure that you can use to create them. You don't need to have any experience of using Microsoft Azure before taking this course, but a basic level of familiarity with computer technology and the Internet is assumed. Some of the concepts covered in the course require a basic understanding of mathematics, such as the ability to interpret charts. The course includes hands-on activities that involve working with data and running code, so a knowledge of fundamental programming principles will be helpful. Course Syllabus You can prepare in instructor-led training or self-paced study Learning Path Microsoft Azure AI Fundamentals: AI Overview o3 Modules oBeginner oAI Engineer oAzure AI Bot Service 70% Learning Path Microsoft Azure AI Fundamentals: Computer Vision 3 Modules Beginner AI Engineer Azure 97% Learning Path Microsoft Azure AI Fundamentals: Natural Language Processing 5 Modules Beginner AI Engineer Azure Portal 95% Learning Path Microsoft Azure AI Fundamentals: Document Intelligence and Knowledge Mining 2 Modules Beginner AI Engineer Azure Completed Learning Path Microsoft Azure AI Fundamentals: Generative AI 1 of 4 modules completed Beginner AI Engineer Azure OpenAI Service 20% 1000 XP Embrace responsible AI principles and practices 51 min Module 9 Units Beginner Business Owner Business User Azure Dynamics 365 Microsoft 365 This module is designed to help you adopt responsible AI practices. It offers an overview of the principles, governance system, and procedures followed at Microsoft, but we encourage you to develop your own AI strategy. Learning objectives In this module, you will: Prepare for the implications of responsible AI Describe principles of responsible AI Establish a system for AI governance Take actions for AI governance Engage across teams and organizations to implement responsible AI principles Take inspiration from Fundamentals of Generative AI 9 min remaining Module 11 Units Beginner AI Engineer Developer Solution Architect Student Azure OpenAI Service In this module, you explore the way in which language models enable AI applications and services to generate original content based on natural language input. You also learn how generative AI enables the creation of copilots that can assist humans in creative tasks. Learning objectives By the end of this module, you are able to: Understand generative AI's place in the development of artificial intelligence. Understand language models and their role in intelligent applications. Describe examples of Microsoft Copilot, agents, and good prompts. Knowledge check Completed 200 XP Module assessment 3 minutes 1. What are Large Language Models? Models that detect additional meaning in paragraphs of text. Lists of words and code that computers use to generate text. Models that use deep learning to process and understand natural language on a massive scale. 2. Which Microsoft Copilot should a customer support agent use to research and resolve a support issue? Microsoft Copilot for Microsoft Edge Microsoft Copilot in Dynamics 365 Customer Service Copilot for Security 3. Which tool should a professional developer use to build a custom copilot and deploy it as a service endpoint in Azure? Copilot for Azure Microsoft Copilot Studio Microsoft Azure AI Foundry AI units

complete: Having an issue? We can help! 3. 3900 XP Craft effective prompts for Microsoft 365 Copilot ☑ hr 10 min ☐Learning Path ☐0 of 4 modules completed At a glance ☆Level Beginner ☆Skill Create effective prompts for Microsoft Copilot for Microsoft 365 ☆Product Microsoft Copilot Microsoft 365 Microsoft 365 Apps Word PowerPoint Excel Outlook Microsoft Teams OneNote ☐Role Business User ☐Subject Business applications Productivity Artificial intelligence Discover ways to craft effective and contextual prompts for Microsoft 365 Copilot that create, simplify, transform, and compile content across Microsoft 365 applications. Learn the importance of providing a clear goal, context, source, and expectation in your prompt for the best results. This course covers real world scenarios and examples using Copilot in Microsoft 365 apps like Word, Excel, PowerPoint, Teams, Outlook, OneNote, and Chat. Note This content was partially created with the help of AI. An author reviewed and revised the content as needed. Read more. Prerequisites Learners should have completed the following content prior to this course: ☐Fundamentals of Generative AI ☐Get started with Microsoft 365 Copilot Developer Accelerate app development by using GitHub Copilot Find out how to use GitHub Copilot to interpret and document code, author new code features more efficiently, and refactor, debug, and test code. Build AI apps with Azure Services and best practices Get the details on designing and building a cloud-native AI app, developing a back-end database, and integrating Azure AI services into applications. Build and extend copilots with Microsoft Copilot Studio Use Microsoft Copilot Studio to create conversational AI solutions, and learn how to build actions that extend Microsoft 365 Copilot. Extend Microsoft 365 Copilot (for developers) Use Copilot Studio actions, and learn about building plugins and connectors for Microsoft 365 Copilot. Discover how to choose the right option for your a- business or technical leader Transform your business with Microsoft AI In this learning path, business leaders will find the knowledge and resources to adopt AI in their organizations. Explore planning, strategizing, and scaling AI projects in a responsible way. Implement data integration and model grounding with Azure AI Foundry and Microsoft Fabric Discover how to create advanced AI solutions, ground models in their data, connect and integrate data from various sources, and use OneLake in Microsoft Fabric. Accelerate gen AI model selection, evaluation, and multimodal integration with Azure AI Foundry Find out how to benchmark models, apply multimodal models to help enhance customer satisfaction, and complete evaluations to help ensure performance and safety. Unlocking business potential with AI solutions Learn how to initiate your organization's AI strategy, assess infrastructure readiness, and understand the business impact of AI Business user Design a dream destination using Microsoft Copilot Bring your personal creativity and passion to dream up a novel destination and create the content to help tell its story. Interact with Microsoft Copilot to learn about the capabilities of generative AI Build your skills for working with Microsoft 365 Copilot using this learning path. Explore ways to craft effective and contextual prompts for Microsoft 365 Copilot to help enhance your creativity with Microsoft Copilot. By the end of this learning path, you'll explore how to use Microsoft Copilot to help you research, find information, and generate Data scientist Make your data AI ready with Microsoft Fabric Discover how to implement large-scale data engineering, lakehouse, and warehouse solutions using Microsoft Fabric. Build the skills to use Fabric to effectively manage and analyze data. Run data analytics solutions with Azure Databricks Work with Apache Spark and Azure Databricks to run large data engineering workloads in the cloud, and use Azure Databricks for comprehensive data analytics solutions. IT professional Get AI-Ready with Microsoft 365 Admin This content helps admins ensure that Microsoft 365 tenants are set up and configured for AI so that future AI features can be integrated as seamlessly as possible. Discover Microsoft 365 Copilot (for administrators) Focus on security and compliance features to configure in your Microsoft 365 tenant to help protect your organizational data before you implement Microsoft 365 Copilot. Low-code developer Create Power Platform solutions with AI and Copilot Learn to use Copilot to set up Dataverse, create Power Apps, and build Automated Process ☐ Explore what Microsoft Copilot Studio can do to help you build and extend copilots. Accelerate app development with low-code Learn how to develop web and responsive Power Apps, and Power Automate. This accelerated content will also cover creation of custom copilots with Microsoft Copilot Studio. Extend Microsoft 365 Copilot (for developers) Use Copilot Studio actions, and learn about building plugins and connectors for Microsoft 365 Copilot. Discover how to choose the right option for your use case. Build and extend copilots with Microsoft Copilot Studio Use Microsoft Copilot Studio to create conversational AI solutions, and learn how to build actions that extend Microsoft 365 Copilot. ecurity professional Help secure your data in the age of AI Work with Microsoft Purview, Microsoft Sentinel, and Microsoft Copilot for Security, and learn how to effectively manage, protect, and govern sensitive information in AI-driven environments. Plan Help secure your data in the age of AI 3 milestones This Plan is designed to offer you interactive experience working with Microsoft technologies, including Microsoft Purview, Microsoft Sentinel, and Microsoft Copilot for Security, so you can effectively manage, protect, and govern sensitive information in AI-driven environments. Discover how to create a secure and compliant data estate that is ready to adapt to AI • Secure your data

syndicationFeed = syndicationClient.RetrieveFeedAsync(rssFeedUri).get(); SyndicationClient::RetrieveFeedAsync is an example of an asynchronous Windows Runtime function. The code example receives an asynchronous operation object from RetrieveFeedAsync, and it calls get on that object to block the calling thread and wait for the result (which is a syndication feed, in this case). For more about concurrency, and for non-blocking techniques, see Concurrency and asynchronous operations with C++/WinRT. C++/WinRT for (const SyndicationItem syndicationItem : syndicationFeed.Items()) { ... } SyndicationFeed.Items is a range, defined by the iterators returned from begin and end functions (or their constant, reverse, and constant-reverse variants). Because of this, you can enumerate Items with either a range-based for statement, or with the std::for_each template function. Whenever you iterate over a Windows Runtime collection like this, you'll need to #include . C++/WinRT winrt::hstring titleAsHstring = syndicationItem.Title().Text(); // Omitted: there's a little bit of extra work here to remove the trademark symbol from the title text.std::wcout << titleAsHstring.c_str() < Windows Desktop > Windows Desktop Application project. You can optionally install the C++/WinRT Visual Studio Extension (VSIX) and the NuGet package. For details, see Visual Studio support for C++/WinRT. Set project properties Go to project property General > Windows SDK Version, and select All Configurations and All Platforms. Ensure that Windows SDK Version is set to 10.0.17134.0 (Windows 10, version 1803) or greater. Confirm that you're not affected by Why won't my new project compile?. Because C++/WinRT uses features from the C++17 standard, set project property C/C++ > Language > C++ Language Standard to ISO C++17 Standard (/std:c++17).The precompiled header The default project template creates a precompiled header for you, named either framework.h , or stdafx.h . Rename that to pch.h . If you have a stdafx.cpp file, then rename that to pch.cpp . Set project property C/C++ > Precompiled Headers > Precompiled Header to Create (/Yc), and Precompiled Header File to pch.h. Find and replace all #include "framework.h" (or #include "stdafx.h") with #include "pch.h" . In pch.h , include winrt/base.h . C++/WinRT // pch.h ... #include Linking The C++/WinRT language projection depends on certain Windows Runtime free (non member) functions, and entry points, that require linking to the WindowsApp.lib umbrella library. This section describes three ways of satisfying the linker. The first option is to add to your Visual Studio project all of the C++/WinRT MSBuild properties and targets. To do this, install the Microsoft.Windows.CppWinRT NuGet package into your project. Open the project in Visual Studio, click Project > Manage NuGet Packages... > Browse, type or paste Microsoft.Windows.CppWinRT in the search box, select the item in search results, and then click Install to install the package for that project. You can also use project link settings to explicitly link WindowsApp.lib . Or, you can do it in source code (in pch.h , for example) like this. C++/WinRT #pragma comment(lib, "windowsapp") You can now compile and link, and add C++/WinRT code to your project (for example, code similar to that shown in the A C++/WinRT quick-start section, above). The three main scenarios for C++/WinRTAs you use and become familiar with C++/WinRT, and work through the rest of the documentation here, you'll likely notice that there are three main scenarios, as described in the following sections. Consuming Windows APIs and types In other words, using, or calling APIs. For example, making API calls to communicate using Bluetooth; to stream and present video; to integrate with the Windows shell; and so on. C++/WinRT fully and uncompromisingly supports this category of scenario. For more info, see Consume APIs with C++/WinRT. Authoring Windows APIs and types In other words, producing APIs and types. For example, producing the kinds of APIs described in the section above; or the graphics APIs; the storage and file system APIs; the networking APIs, and so on. For more info, see Author APIs with C++/WinRT. Authoring APIs with C++/WinRT is a little more involved than consuming them, because you must use IDL to define the shape of the API before you can implement it. There's a walkthrough of doing that in XAML controls; bind to a C++/WinRT property. XAML applications This scenario is about building applications and controls on the XAML UI framework. Working in a XAML application amounts to a combination of consuming and authoring. But since XAML is the dominant UI framework on Windows today, and its influence over the Windows Runtime is proportionate to that, it deserves its own category of scenario. Be aware that XAML works best with programming languages that offer reflection. In C++/WinRT, you sometimes have to do a little extra work in order to interoperate with the XAML framework. All of those cases are covered in the documentation. Good places to start are XAML controls; bind to a C++/WinRT property and XAML custom (templated) controls with C++/WinRT. Sample apps written in C++/WinRT See Where can I find C++/WinRT sample apps?. Important APIs Feedback Was this page helpful? Provide product feedback Get help at Microsoft Q&A SyndicationClient::RetrieveFeedAsync method SyndicationFeed.Items property winrt::hstring struct winrt::hresult-error struct C++/CX Error handling with C++/WinRT Interop between C++/WinRT and C++/CX Interop between C++/WinRT and the ABI Move to C++/WinRT from C++/CX String handling in C++/WinRT Related topics Yes No Feedback Was this page helpful? Get help at Microsoft Q&A Get Started with Win32 and C++ Article • 01/27/2022 The aim of this Get Started series is to teach you how to write a desktop program in C++ using Win32 and COM APIs. In the first module, you'll learn step-by-step how to create and show a window. Later modules will introduce the Component Object Model (COM), graphics and text, and user input. For this series, it is assumed that you have a good working knowledge of C++ programming. No previous experience with Windows programming is assumed. If you are new to C++, learning material is available in the C++ language documentation . Topic Description Intro to Win32 programming in C++ This section describes some of the basic terminology and coding conventions used in Windows programming. Module 1. Your First Windows Program In this module, you will create a simple Windows program that shows a blank window. Module 2. Using COM in Your Windows Program This module introduces the Component Object Model (COM), which underlies many of the modern Windows APIs. Module 3. Windows Graphics This module introduces the Windows graphics architecture, with a focus on Direct2D. Module 4. User Input This module describes mouse and keyboard input. Sample Code Contains links to download the sample code for this series. In this section Yes No Create a simple Universal Windows Platform (UWP) game with DirectX Article • 10/20/2022 In this set of tutorials, you'll learn how to use DirectX and C++/WinRT to create the basic Universal Windows Platform (UWP) sample game named Simple3DGameDX. The gameplay takes place in a simple first-person 3D shooting gallery. 7 Note The link from which you can download the Simple3DGameDX sample game itself is Direct3D sample game. The C++/WinRT source code is in the folder named cppwinrt . For info about other UWP sample apps, see Sample applications for Windows development. These tutorials cover all of the major parts of a game, including the processes for loading assets such as arts and meshes, creating a main game loop, implementing a simple rendering pipeline, and adding sound and controls.

Directories dialog box to Enable an edit control. In the edit control, specify the path to the MathLibrary.lib file. By default, it's in a folder called Debug directly under the DLL Solution folder. If you create a release build, the file is placed in a folder called Release. You can use the $(IntDir) macro so that the linker can find your DLL, no matter which kind of build you create. If you followed the directions to put your Client project in a separate solution from the DLL project, you must specify the full path to the library file. In the Additional Library Directories dialog box, choose the OK button to go back to the Property Pages dialog box. Choose OK to save the property changes. Your client app can now compile and link successfully, but it still doesn't have everything it needs to run. When the operating system loads your app, it looks for the MathLibrary.dll. If it can't find the DLL in certain system directories, the environment path, or the local app directory, the load fails. Depending on the operating system, you'll see an error message like this: One way to avoid this issue is to copy the DLL to the directory that contains your client executable as part of the build process. You can add a Post-Build Event to your project, to add a command that copies the DLL to your build output directory. The command specified here copies the DLL only if it's missing or has changed. It uses macros to copy to and from the Debug or Release locations, based on your build configuration. To copy the DLL in a post-build event: Right-click on the MathClient node in Solution Explorer and choose Properties to Open the Property Pages dialog. In the Configuration drop-down box, select All Configurations if it isn't already selected. In the left pane, select Configuration Properties > Build Events > Post-Build Event. In the property pane, select the edit control in the Command Line field. If you followed the directions to put your client project in a separate solution from the DLL project, then enter this command: xcopy /y /d "..\..\MathLibrary$(IntDir)MathLibrary.dll" "$(OutDir)" If your DLL and client projects are in other directories, change the relative path to the DLL to match. Choose the OK button to save your changes to the project properties. Now your client app has everything it needs to build and run. Build the application by choosing Build > Build Solution on the menu bar. The Output window in Visual Studio should have something like the following example depending on your version of Visual Studio: Output 1>------ Build started: Project: MathClient, Configuration: Debug Win32 ---- 1>1>MathClient.cpp 1>1>MathClient.vcxproj -> C:\Users\username\Source\Repos\MathClient\Debug\MathClient.exe ========== Build: 1 succeeded, 0 failed, 0 up-to-date, 0 skipped ========== Congratulations, you've created an application that calls functions in your DLL. Now run your application to see what it does. On the menu bar, choose Debug > Start Without Debugging. Visual Studio builds your client app, if necessary, and then runs it. The last line of output from the example app is: Press any key to continue. Press any key to close the console window. You can experiment. Try setting breakpoints in the code of the client file—for example, MathLibrary.h—and then choose the Add button. A nearly blank header file is displayed. Add a declaration for a class named Arithmetic to do common mathematical operations such as addition, subtraction, multiplication, and division. The code should resemble: C++ Add a class to the static library To add a class to the static library: MathLibrary.h pragma once namespace MathLibrary { class Arithmetic { public: // Returns a + b static double Add(double a, double b); // Returns a - b static double Subtract(double a, double b);}; To create a source file for the new class, open the shortcut menu for the MathLibrary project in Solution Explorer, and then choose Add > New Item. In the Add New Item dialog box, in the center pane, select C++ File (.cpp). Specify the name for the source file—for example, MathLibrary.cpp—and then choose the Add button. A blank source file is displayed. In the source file to implement the functionality for class Arithmetic. The code should resemble: C++ // Returns a + b double Arithmetic::Add(double a, double b) { return a + b; } // Returns a - b double Arithmetic::Subtract(double a, double b) { return a - b; } Add the header file to the static library To add the header file to the static library: MathLibrary.cpp #include "MathLibrary.h" #include <exception> // Returns a + b double Arithmetic::Add(double a, double b) { return a + b; } // Returns a - b double Arithmetic::Subtract(double a, double b) { return a - b; } // Returns a / b; throws exception if b is 0 double Arithmetic::Divide(double a, double b) { if (b == 0) throw "Divide by zero!"; return a / b; } Compile the static library The code is now complete. Build the static library to create a .lib file that contains the compiled code. Choose Build > Build Solution on the menu bar. The build creates a static library, MathLibrary.lib, that can be used by other programs. Use the static library in a client app Now that you've built a static library, you can use it in your own code. To use the static library in another app, you must: Add a reference to the .lib file to the project. Add a #include statement for the library's header file to your code. Add the path to the .lib file to the Additional Library Directories property, specify the path of the MathLibrary directory, or browse for it. To browse for the directory path: In Solution Explorer, right-click on MathClient and choose Properties to open the Property Pages dialog box. In the left pane, select Configuration Properties > VC++ Directories. In the property page, select the Additional Include Directories property, specify the path of the MathLibrary directory, or browse for it. To browse for the directory path: In the Additional Include Directories property value drop-down list, and then choose Edit. In the Additional Include Directories dialog box, double-click in the top of the text box. Then choose the ellipsis button (...) at the end of the line. In the Select Directory dialog box, navigate up a level, and then select the MathLibrary directory. Then choose the Select Folder button to save your selection. In the Additional Include Directories dialog box, choose the OK button. In the Property Pages dialog box, choose the OK button to save your changes to the project. Now you can use the Arithmetic class in this app by including the #include "MathLibrary.h" header in your code. Replace the contents of MathClient.cpp with this code: C++ // compile with: /EHsc /link MathLibrary.lib #include <iostream> #include "MathLibrary.h" int main() { double a = 7.4; int b = 99; std::cout << "a + b = " << MathLibrary::Arithmetic::Add(a, b) << std::endl; std::cout << "a - b = " << MathLibrary::Arithmetic::Subtract(a, b) << std::endl; std::cout << "a * b = " << MathLibrary::Arithmetic::Multiply(a, b) << std::endl; std::cout << "a / b = " << MathLibrary::Arithmetic::Divide(a, b) < Source Control > Git Global Settings > Automatically load the solution when opening a Git repository. Open a project locally from a recently cloned GitHub repo 1. Open Visual Studio. 2. On the start window, select Clone a repository. 3. In the Browse a repository section, select Azure DevOps. 4. Follow the prompts to clone an Azure DevOps repo that includes the files that you're looking for, and then open your project. Related content Feel free to dive into any of the following language-specific tutorials:Feedback This was this page helpful? Provide product feedback Ask the community Visual Studio tutorials | C# Visual Studio tutorials | Visual Basic Visual Studio tutorials | C++ Visual Studio tutorials | Python Visual Studio tutorials | JavaScript, TypeScript, and Node.js For more information, see: About Git in Visual Studio Browse a repo Manage a repo Tip Yes No Learn to use the code editor Article 01/24/2025 In this 10-minute introduction to the code editor in Visual Studio, we'll add code to a file to look at some of the ways that Visual Studio makes writing, navigating, and understanding code easier. Prerequisites You don't need any previously installed Visual Studio tools for this tutorial, but you'll need to have Visual Studio installed with the .NET desktop development workload. If you don't have Visual Studio installed, you can download and install it for free. Output // Main Client.cpp // compile with: /EHsc /link MathLibrary.lib #include <iostream> #include "MathLibrary.h" int main() { double a = 7.4; int b = 99; std::cout << "a + b = " << MathLibrary::Arithmetic::Add(a, b) << std::endl; std::cout << "a - b = " << MathLibrary::Arithmetic::Subtract(a, b) << std::endl; std::cout << "a * b = " << MathLibrary::Arithmetic::Multiply(a, b) << std::endl; std::cout << "a / b = " << MathLibrary::Arithmetic::Divide(a, b) < Source Control > Git Global Settings > Automatically load the solution when opening a Git repository. Open a project locally from a recently cloned GitHub repo 1. Open Visual Studio. 2. On the start window, select Clone a repository. Visual Studio opens an instance of File Explorer, where you can browse to your solution or project, and then select it to open it. Tip If you opened the project or solution recently, select it from the Open recent section. Start coding Use the IDE You can also use the Git menu or the Select Repository control in the Visual Studio IDE to interact with a repository's folders and files.Here's how. To clone a repo and open a project 1. In the Visual Studio IDE, select the Git menu, and then select Clone Repository. Or, if you're in the Select Repository control, select Clone a repository. 2. In the Clone a repository dialog box, in the Location section, enter the URL of the repo you want to connect to the Repository location. 3. Follow the prompts to connect to the repo that has the files that you're looking for. Browse to an Azure DevOps repo Here's how to browse to and clone an Azure DevOps repo by using Visual Studio. 1. Open Visual Studio. 2. On the start window, select Clone a repository. 3. In the Browse a repository section, select Azure DevOps. 4. Follow the prompts to clone an Azure DevOps repo that includes the files that you're looking for, and then open your project. Related content Feel free to dive into any of the following language-specific tutorials:Feedback This was this page helpful? Provide product feedback Ask the community Visual Studio tutorials | C# Visual Studio tutorials | Visual Basic Visual Studio tutorials | C++ Visual Studio tutorials | Python Visual Studio tutorials | JavaScript, TypeScript, and Node.js For more information, see: About Git in Visual Studio Browse a repo Manage a repo Tip Yes No Learn to use the code editor Article 01/24/2025 In this 10-minute introduction to the code editor in Visual Studio, we'll add code to a file to look at some of the ways that Visual Studio makes writing, navigating, and understanding code easier. Prerequisites You don't need any previously installed Visual Studio tools for this tutorial, but you'll need to have Visual Studio installed with the .NET desktop development workload. If you don't have Visual Studio installed, you can download and install it for free. Output // Main Client.cpp // compile with: /EHsc /link MathLibrary.lib #include <iostream> #include "MathLibrary.h" int main() { double a = 7.4; int b = 99; std::cout << "a + b = " << MathLibrary::Arithmetic::Add(a, b) << std::endl; such as create a web app with Python or C#, or create a console app with Visual Basic or C++. Tip To follow along with this article, make sure you have the C# settings selected for Visual Studio. For information about selecting settings for the integrated development environment (IDE), see Select environment settings. Create a new code file Start by creating a new file and adding some code to it. 1. Open Visual Studio. Select the Esc key, or select Continue without code on the start window, to open the development environment. 2. From the File menu on the menu bar, select New > File, or select the Ctrl+N keys. 3. In the New File dialog box, under the General category, select C# Class, and then select Open. A new file opens in the editor with the skeleton of a C# class.Use GitHub Copilot GitHub Copilot acts as an AI pair programmer to provide autocomplete-style code completions and context-aware multi-line code suggestions, as you code, in real-time. Right in the editor. GitHub Copilot turns natural language prompts including comments and test method names into coding suggestions. You can view and incorporate the suggestions. From GitHub Copilot directly within the Visual Studio editor. Try GitHub Copilot in Visual Studio for free. Set up GitHub Copilot 1. Sign in to your GitHub account. 2. Type a natural language comment, such as // create a method that adds two numbers and Enter. 3. GitHub Copilot generates a code suggestion for you. The suggested implementation shows in gray text. 4. To accept the suggestion, select Tab. Let's use Copilot Chat to submit a coding-related question as a prompt: 1. Select the GitHub Copilot badge in the upper-right corner of the IDE. 2. Select Open Chat Window from the dropdown. 3. Enter the following prompt in the chat window: Copilot prompt Generate sample code for a simple C# method to add two numbers. 4. Copilot Chat generates sample code in response to your prompt. GitHub Copilot is powered by AI, so surprises and mistakes are possible. For more information, see GitHub Copilot FAQs . Get started with GitHub Copilot in Visual Studio. Note that it requires Visual Studio 2022 Version 17.8 or later. Use code snippets Visual Studio provides useful code snippets that you can use to quickly and easily generate commonly used code blocks. Code snippets are available for different programming languages including C#, Visual Basic, and C++. Let's add the C# method snippet to our file. 1. Open the Solution Explorer by selecting Ctrl+Alt+L. Customize your code snippets Visual Studio provides a way to edit and customize your code snippets. With information about the code snippet. You'll see the code snippet method signature get added to the file. The Main() method is the entry point for C# applications. Available code snippets vary for different programming languages. You can look at the available code snippets for your language by choosing Edit > IntelliSense > Insert Snippet or by selecting the Ctrl+K, Ctrl+X keys, and then choosing the folder for your programming language. For C#, the snippet list looks like this:The list includes snippets for creating a class, a constructor, a for loop, an if or switch statement, and more. The Text Editor toolbar, which is the row of buttons under the menu bar in Visual Studio, helps make you more productive as you code. For example, you can toggle IntelliSense completion mode, increase or decrease a line indent, or comment out code that you don't want to compile. Let's comment out some of the Main() method body. For C#, Comment out the selected lines with "//". Type "public", "for", "quick", "prop", "ctor", "cw", "try", "switch", "if", "while", "do", "foreach", "#if", "#region", "class", "interface", "struct", "enum", "namespace", "equals", "gethash", "tostring", "dispose", "iequatable", "operator", "exception", "propfull", "propg", "props", "ctor", "sim", "indexer", "iequatable

source code into an .obj file, and then runs the linker to generate an executable program named basiccx.exe. The /EHsc compiler option specifies the C++ exception-handling model, and the /link flag specifies a console application. 7. To run the basiccx.exe program, at the command prompt, enter basiccx. The program displays this text and exits: Output This is a C++/CX program. See also Projects and build systems MSVC Compiler OptionsWalkthrough: Compiling a C++/CLI Program on the Command Line Article • 02/24/2023 You can create Visual C++ programs that target the Common Language Runtime (CLR) and use the .NET Framework, and build them on the command line. Visual C++ supports the C++/CLI programming language, which has additional types and operators to target the .NET programming model. For general information about the C++/CLI language, see .NET Programming with C++/CLI (Visual C++). In this walkthrough, you use a text editor to create a basic C++/CLI program, and then compile it on the command line. (You can use your own C++/CLI program instead of typing the one that's shown, or you can use a C++/CLI code sample from another help article. This technique is useful for building and testing small modules that have no UI elements.) Prerequisites You understand the fundamentals of the C++ language. Compile a C++/CLI Program The following steps show how to compile a C++/CLI console application that uses .NET Framework classes. To enable compilation for C++/CLI, you must use the /clr compiler option. The MSVC compiler generates an .exe file that contains MSIL code—or mixed MSIL and native code—and links to the required .NET Framework libraries. To compile a C++/CLI application on the command line 1. Open a Developer Command Prompt window. For specific instructions, see To open a developer command prompt window. Administrator credentials may be required to successfully compile the code, depending on the computer's operating system and configuration. To run the command prompt window as an administrator, right-click to open the shortcut menu for the command prompt and then choose More > Run as administrator.2. Change the current working directory in the command prompt window to a directory you can write to, such as your Documents directory. 3. At the command prompt, enter notepad basicclr.cpp . Choose Yes when you're prompted to create a file. 4. In Notepad, enter these lines: C++ int main() { System::Console::WriteLine("This is a C++/CLI program."); } 5. On the menu bar, choose File > Save. You've created a Visual C++ source file that uses a .NET Framework class (Console) in the System namespace. 6. At the command prompt, enter cl /clr basicclr.cpp . The cl.exe compiler compiles the source code into an .obj file that contains MSIL, and then runs the linker to generate an executable program named basicclr.exe. 7. To run the basicclr.exe program, at the command prompt, enter basicclr . The program displays this text and exits: Output This is a C++/CLI program. See also C++ Language Reference Projects and build systems MSVC Compiler Options 2. C++ Standard Library reference (STL) Article 08/17/2022 A C++ program can call on a large number of functions from this conforming implementation of the C++ Standard Library. These functions perform services such as input and output and provide efficient implementations of frequently used operations. For more information about linking with the appropriate Visual C++ runtime .lib file, see C runtime (CRT) and C++ Standard Library (STL) .lib files. Note Microsoft's implementation of the C++ Standard Library is often referred to as the STL or Standard Template Library. Although C++ Standard Library is the official name of the library as defined in ISO 14882, due to the popular use of "STL" and "Standard Template Library" in search engines, we occasionally use those names to make it easier to find our documentation. From a historical perspective, "STL" originally referred to the Standard Template Library written by Alexander Stepanov. Parts of that library were standardized in the C++ Standard Library, along with the ISO C runtime library, parts of the Boost library, and other functionality. Sometimes "STL" is used to refer to the containers and algorithms parts of the C++ Standard Library adapted from Stepanov's STL. In this documentation, Standard Template Library (STL) refers to the C++ Standard Library as a whole. In this section C++ Standard Library overview Provides an overview of the Microsoft implementation of the C++ Standard Library. iostream programming Provides an overview of iostream programming. Header files reference Provides links to reference topics about the C++ Standard Library header files, with code examples. Use the Microsoft C++ toolset from the command line Article 03/02/2023 In this article 1.Download and install the tools 2.How to use the command-line tools 3.Path and environment variables for command-line builds 4.Developer command prompt shortcuts You can build C and C++ applications on the command line by using tools that are included in Visual Studio. The Microsoft C++ (MSVC) compiler toolset is also downloadable as a standalone package. You don't need to install the Visual Studio IDE if you don't plan to use it. Note This article is about how to set up an environment to use the individual compilers, linkers, librarian, and other basic tools. The native project build system in Visual Studio, based on MSBuild, doesn't use the environment as described in this article. For more information on how to use MSBuild from the command line, see MSBuild on the command line - C++. Download and install the tools If you've installed Visual Studio and a C++ workload, you have all the command-line tools. For information on how to install C++ and Visual Studio, see Install C++ support in Visual Studio. If you only want the command-line toolset, download the Build Tools for Visual Studio. When you run the downloaded executable, it updates and runs the Visual Studio Installer. To install only the tools you need for C++ development, select the Desktop development with C++ workload. You can select optional libraries and toolsets to include under Installation details. To build code by using the Visual Studio 2015, 2017, or 2019 toolsets, select the optional MSVC v140, v141, or v142 build tools. When you're satisfied with your selections, choose Install. How to use the command-line tools When you choose one of the C++ workloads in the Visual Studio Installer, it installs the Visual Studio platform toolset. A platform toolset has all the C and C++ tools for a specific Visual Studio version. The tools include the C/C++ compilers, linkers, assemblers, and other build tools, and matching libraries and header files. You can use all of these tools at the command line. They're also used internally by the Visual Studio IDE. There are separate x86-hosted and x64-hosted compilers and tools to build code for x86, x64, ARM, and ARM64 targets. Each set of tools for a particular host and target build architecture is stored in its own directory. To work correctly, the tools require several specific environment variables to be set. These variables are used to add the tools to the path, and to set the locations of include files, library files, and SDKs. To make it easy to set these environment variables, the installer creates customized command files, or batch files, during installation. You can run one of these command files to set a specific host and target build architecture, Windows SDK version, and platform toolset. For convenience, the installer also creates shortcuts in your Start menu. The shortcuts open developer command prompt windows by using these command files for specific combinations of host and target. These shortcuts ensure all the required environment variables are set and ready to use. The required environment variables are specific to your installation and to the build architecture you choose. They also might be changed by product updates or upgrades. This variability is one reason why we recommend you use an installed command prompt shortcut or command file, instead of setting the environment variables yourself. The toolsets, command files, and shortcuts installed depend on your computer processor and the options you selected during installation. The x86-hosted tools and cross tools that build x86 and x64 code are always installed. If you have 64-bit Windows, the x64-hosted tools and cross tools that build x86 and x64 code are also installed. If you choose the optional C++ Universal Windows Platform tools, then the x86 and x64 tools that build ARM and ARM64 code also get installed. Other workloads may install these and other tools. Path and environment variables for command-line builds The MSVC command-line tools use the PATH, TMP, INCLUDE, LIB, and LIBPATH environment variables, and also use other environment variables specific to your installed tools, platforms, and SDKs. Even a simple Visual Studio installation may set twenty or more environment variables. This complexity is why we strongly recommend that you use a developer command prompt shortcut or one of the customized command files. We don't recommend you set these variables in the Windows environment yourself. To see which environment variables are set by a developer command prompt shortcut, you can use the SET command. Open a plain command prompt window and capture the output of the SET command for a baseline. Open a developer command prompt window and capture the output of the SET command for comparison. Use a diff tool such as the one built into Visual Studio to highlight the environment variables set by the developer command prompt. For more information about the compiler and linker environment variables, see CL environment variables. Developer command prompt shortcuts The command prompt shortcuts are installed in a version-specific Visual Studio folder in your Windows Start menu. Here's a list of the base command prompt shortcuts and the build architectures they support: Developer Command Prompt - Sets the environment to use 32-bit, x86-native tools to build 32-bit, x86-native code. x86 Native Tools Command Prompt - Sets the environment to use 32-bit, x86-native tools to build 32-bit, x86-native code. x64 Native Tools Command Prompt - Sets the environment to use 64-bit, x64-native tools to build 64-bit, x64-native code. x86_x64 Cross Tools Command Prompt - Sets the environment to use 32-bit, x86-native tools to build 64-bit, x64-native code. x64_x86 Cross Tools Command Prompt - Sets the environment to use 64-bit, x64-native tools to build 32-bit, x86-native code. The Start menu folder and shortcut names vary depending on the installed version of Visual Studio. If you set one, they also depend on the installation Nickname. For example, suppose you installed Visual Studio 2022, and you gave it a nickname of Latest. The developer command prompt shortcut is named Developer Command Prompt for VS 2022 (Latest), in a folder named Visual Studio 2022. Note Several command-line tools or tool options may require Administrator permission. If you have permission issues when you use them, we recommend that you open the developer command prompt window by using the Run as Administrator option. Right-click to open the shortcut menu for the command prompt window, then choose More, Run as administrator. To open a developer command prompt window 1.On the desktop, open the Windows Start menu. In Windows 11, choose the All apps button to open the list of installed apps. In Windows 10, the list is open to the left. Scroll down the list to find and open the folder (not the app) for your version of Visual Studio, for example, Visual Studio 2022. 2.In the folder, choose the Developer Command Prompt for your version of Visual Studio. This shortcut starts a developer command prompt window that uses the default build architecture of 32-bit, x86-native tools to build 32-bit, x86-native code. If you prefer a non-default build architecture, choose one of the native or cross tools command prompts to specify the host and target architecture. For an even faster way to open a developer command prompt, enter developer command prompt in the desktop search box. Then choose the result you want. Note By default, the current working directory in a developer command prompt is the root of your Visual Studio installation in the Program Files directory. This isn't an appropriate location for your code and projects. Change the current working directory to another location before you create a project. The IDE creates projects in your user directory, typically in %USERPROFILE%\source\repos. Developer command file locations If you prefer to set the build environment in an existing command prompt window, you can use one of the command files created by the installer. We recommend you set the environment in a new command prompt window. We don't recommend you later switch environments in the same command window. The command file location depends on the version of Visual Studio you installed, and on choices you made during installation. For Visual Studio 2019, the typical installation location on a 64-bit system is in \Program Files\Microsoft Visual Studio\2022\. The may be Community, Professional, Enterprise, BuildTools, or another nickname you supplied. The primary developer command prompt command file, VsDevCmd.bat, is located in the Common7\Tools subdirectory. When no parameters are specified, it sets the environment to use the x86-native tools to build 32-bit x86 code. More command files are available to set up specific build architectures. The command files available depend on the Visual Studio workloads and options you've installed. In Visual Studio 2017 and Visual Studio 2019, you'll find them in the VC\Auxiliary\Build subdirectory. These command files set default parameters and call VsDevCmd.bat to set up the specified build architecture environment. A typical installation may include these command files: Command File Host and Target architectures vcvars32.bat Use the 32-bit x86-native tools to build 32-bit x86 code. vcvars64.bat Use the 64-bit x64-native tools to build 64-bit x64 code. vcvarsx86_amd64.bat Use the 32-bit x86-native cross tools to build 64-bit x64 code. vcvarsamd64_x86.bat Use the 64-bit x64-native cross tools to build 32-bit x86 code. vcvarsx86_arm.bat Use the 32-bit x86-native cross tools to build ARM code. vcvarsamd64_arm.bat Use the 64-bit x64-native cross tools to build ARM code. vcvarsx86_arm64.bat Use the 32-bit x86-native cross tools to build ARM64 code. vcvarsamd64_arm64.bat Use the 64-bit x64-native cross tools to build ARM64 code. vcvarsall.bat Use parameters to specify the host and target architectures, Windows SDK, and platform choices. For a list of supported options, call by using a /help parameter. Caution The vcvarsall.bat file and other Visual Studio command files can vary from computer to computer. Do not replace a missing or damaged vcvarsall.bat file by using a file from another computer. Rerun the Visual Studio installer to replace the missing file. The vcvarsall.bat file also varies from version to version. If the current version of Visual Studio is installed on a computer that also has an earlier version of Visual Studio, do not run vcvarsall.bat or another Visual Studio command file from different versions in the same command prompt window. Use the developer tools in an existing command window The simplest way to specify a particular build architecture in an existing command window is to use the vcvarsall.bat file. Use vcvarsall.bat to set environment variables to configure the command line for native 32-bit or 64-bit compilation. Arguments let you specify cross-compilation to x86, x64, ARM, or ARM64 processors. You can target Microsoft Store, Universal Windows Platform, or Windows Desktop platforms. You can even specify which Windows SDK to use, and select the platform toolset version. When used with no arguments, vcvarsall.bat configures the environment variables to use the current x86-native compiler for 32-bit Windows Desktop targets. You can add arguments to configure the environment to use any of the native or cross compiler tools. vcvarsall.bat displays an error message if you specify a configuration that's not installed, or not available on your computer. vcvarsall syntax vcvarsall.bat [architecture] [platform_type] [winsdk_version] [-vcvars_ver=vcversion] [spectre_mode] architecture This optional argument specifies the host and target architecture to use. If architecture isn't specified, the default build environment is used. These arguments are supported: architecture Compiler Host computer architecture Build output (target) architecture x86 x86 32-bit native x86, x64 x86 amd64 x86_amd64 x86_x64 x64 x86 x64 x64 amd64_x86 x64_x86 x64 x64 x86 x86 arm x86_arm x64 x64 ARM arm64 x86_arm64 x64 ARM64 amd64 amd64_x86 x64_x86 x64 x64 x86 on x64 x86_amd64 x86 x86 x64 x86 on x86 cross x64 x86 amd64_arm x64_arm ARM on x64 cross ARM64 amd64_arm64 x64_arm64 ARM64 on x64 cross x64 ARM64 platform_type This optional argument allows you to specify store or uwp as the platform type. By default, the environment is set to build desktop or console apps. winsdk_version Optionally specifies the version of the Windows SDK to use. By default, the latest installed Windows SDK is used. To specify the Windows SDK version, you can use a full Windows SDK number such as 10.0.10240.0, or specify 8.1 to use the Windows 8.1 SDK. vcversion Optionally specifies the Visual Studio compiler toolset to use. By default, the environment is set to use the current Visual Studio compiler toolset. Use -vcvars_ver=14.2x.yyyyy to specify a specific version of the Visual Studio 2019 compiler toolset. Use -vcvars_ver=14.29 to specify the latest version of the Visual Studio 2019 compiler toolset. Use -vcvars_ver=14.0 to specify the Visual Studio 2015 compiler toolset. spectre_mode Leave this parameter out to use libraries without Spectre mitigations. Use the value spectre to use libraries with Spectre mitigations. To set up the build environment in an existing command prompt window 1. At the command prompt, use the CD command to change to the Visual Studio installation directory. Then, use CD again to change to the subdirectory that contains the configuration-specific command files. For Visual Studio 2019 and Visual Studio 2017, use the VC\Auxiliary\Build subdirectory. For Visual Studio 2015, use the VC subdirectory. 2.Enter the command for your preferred developer environment. For example, to build ARM code for UWP on a 64-bit platform, using the latest Windows SDK and Visual Studio compiler toolset, use this command line: vcvarsall.bat amd64_arm uwp Create your own command prompt shortcut Open the Properties dialog for a developer command prompt shortcut to see the command target used. For example, the target for the x64 Native Tools Command Prompt for VS 2019 shortcut is something similar to: %comspec% /k "C:\Program Files (x86)\Microsoft Visual Studio\2019\Community\VC\Auxiliary\Build\vcvars64.bat" The architecture-specific batch files set the architecture parameter and call vcvarsall.bat. You can pass the same options to these batch files as you would pass to vcvarsall.bat, or you can just call vcvarsall.bat directly. To specify parameters for your own command shortcut, add them to the end of the command in double-quotes. For example, here's a shortcut to build ARM code for UWP on a 64-bit platform, using the latest Windows SDK. To use an earlier compiler toolset, specify the version number. Use something like this command target in your shortcut: %comspec% /k "C:\Program Files (x86)\Microsoft Visual Studio\2019\Community\VC\Auxiliary\Build\vcvarsall.bat" amd64_arm uwp -vcvars_ver=14.29 Adjust the path to reflect your Visual Studio installation directory. The vcvarsall.bat file has additional information about specific version numbers. Command-line tools To build a C/C++ project at a command prompt, Visual Studio provides these command-line tools: CL Use the compiler (cl.exe) to compile and link source code files into apps, libraries, and DLLs. Link Use the linker (link.exe) to link compiled object files and libraries into apps and DLLs. When you build on the command line, the F1 command isn't available for instant help. Instead, you can use a search engine to get information about warnings, errors, and messages. You can also download and use the offline help files. To use the search in Microsoft Learn, enter your query in the search box at the top of any article. Command-line project management tools By default, the Visual Studio IDE uses native project build systems based on MSBuild. You can invoke MSBuild directly to build projects without using the IDE. You can also use the devenv command to use Visual Studio to build projects and solutions. Visual Studio also supports build systems based on CMake or NMake. MSBuild Use MSBuild (msbuild.exe) and a project file (.vcxproj) to configure a build and invoke the toolset without loading the Visual Studio IDE. It's equivalent to running the Build project or Build Solution command in the Visual Studio IDE. MSBuild has advantages over the IDE when you build at the command line. You don't have to install the full IDE on all your build servers and build pipelines. You avoid the extra overhead of the IDE. MSBuild runs in containerized build environments, and supports a binary logger. DEVENV Use DEVENV (devenv.exe) combined with a command-line switch such as /Build or /Clean to execute certain build commands without displaying the Visual Studio IDE. CMake CMake (cmake.exe) is a cross-platform, open-source tool for defining build processes that run on multiple platforms. CMake can configure and control native build tools for its supported platforms, such as MSBuild and Make. For more information about CMake, see the CMake documentation. NMAKE Use NMAKE (nmake.exe) to build C++ projects by using a traditional makefile. Note Starting in Visual Studio 2019 version 16.5, MSBuild and DEVENV don't use the command-line environment to control the toolset and libraries used. In this section These articles show how to build apps on the command line, and describe how to customize the command-line build environment. Some show how to use 64-bit toolsets, and target x86, x64, ARM, and ARM64 platforms. They also describe use of the command-line build tools MSBuild and NMAKE. Walkthrough: Compiling a native C++ program on the command line Gives an example that shows how to create and compile a C++ program on the command line. Walkthrough: Compile a C program on the command line Describes how to compile a program written in the C programming language. Walkthrough: Compiling a C++/CLI program on the command line Describes how to create and compile a C++/CLI program that uses the .NET Framework. Walkthrough: Compiling a C++/CX program on the command line Describes how to create and compile a C++/CX program that uses the Windows Runtime. NMAKE reference Provides links to articles that describe the Microsoft Program Maintenance Utility (NMAKE.EXE). MSBuild on the command line - C++ Provides links to articles that discuss how to use msbuild.exe from the command line. Related sections /MD, /MT, /LD (Use run-time library) Describes how to use these compiler options to use a Debug or Release run-time library. C/C++ compiler options Provides links to articles that discuss the C and C++ compiler options and CL.exe. MSVC linker options Provides links to articles that discuss the linker options and LINK.exe. Additional MSVC build tools Provides links to the C/C++ build tools that are included in Visual Studio. See also Azure Virtual Desktop Readiness Resources | Microsoft Partner Opportunity and Use Cases Azure Well-Architected Azure Virtual Desktop Workload Assessment AVD Stories Training Resources Azure Virtual Desktop Academy AVD Academy Resources Azure Virtual Desktop Landing Zone Accelerator (LZA) Roadmap and Best Practices AVD Community Blogs AVD/Citrix/VMware/Azure Stack HCI Bill of Materials AVD Level 300 Customer/Partner Deck ur overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-1 Critical: 0 to 1 MODERATE 1-2 Moderate: 1 to 2 EXCELLENT 2-3 Excellent: 2 to 3 Your result: 3/3 3 out of 3 Categories that influenced your results Azure Virtual Desktop Readiness Resources | Microsoft Partner EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. Azure Virtual Desktop | Microsoft Partner - Mar 4, 2025 - 11:55:56 AM Your overall results Excellent '3/3' Azure Virtual Desktop Readiness Resources | Microsoft Partner Excellent '3/3' Category Link-Text Link Priority ReportingCategory ReportingSubcategory Weight Context CompleteY/N Note Azure Virtual Desktop Readiness Resources | Microsoft Partner Azure Well-Architected Azure Virtual Desktop Workload Assessment https://learn.microsoft.com/en-us/assessments/1ef67c4e-b8d1-4193-b850-d192089ae33d/assessments/6356b690-ba16-4dec-80a3-1e99a2021723?mode=pre-assessment&id=1ef67c4e-b8d1-4193-b850-d192089ae33d&session=6356b690-ba16-4dec-80a3-1e99a2021723 High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner AVD Stories https://azure.microsoft.com/en-us/products/virtual-desktop/#Customerstories High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner Azure Virtual Desktop Academy https://microsoft.github.io/PartnerResources/skilling/microsoft-infrastructure-academy/avd High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner AVD Academy Resources https://microsoft.github.io/PartnerResources/skilling/microsoft-infrastructure-academy/azure-virtual-desktop High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner Azure Virtual Desktop Landing Zone Accelerator (LZA) https://github.com/Azure/avdaccelerator High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner AVD Community Blogs https://techcommunity.microsoft.com/t5/azure-virtual-desktop-blog/bg-p/AzureVirtualDesktopBlog High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner AVD/Citrix/VMware/Azure Stack HCI Bill of Materials https://onedrive.live.com/?authkey=%21ACVW%2Deoxp2ZpM6F&cid=D242F3D2FC2D88CC%21448&id=D242F3D2FC2D88CC High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner AVD Level 300 Customer/Partner Deck https://1drv.ms/p/s!AsyjLfzS80LSiAa_HEmJ_F5WuZRi?e=Osgzmf High 0 N ----------- Category Question Answers Selected Answer Note Azure Virtual Desktop Readiness Resources | Microsoft Partner Opportunity and Use Cases Azure Well-Architected Azure Virtual Desktop Workload Assessment Azure Virtual Desktop Readiness Resources | Microsoft Partner Opportunity and Use Cases AVD Stories AVD Stories Azure Virtual Desktop Readiness Resources | Microsoft Partner Training Resources Azure Virtual Desktop Academy Azure Virtual Desktop Academy Azure Virtual Desktop Readiness Resources | Microsoft Partner Training Resources AVD Academy Resources AVD Academy Resources Azure Virtual Desktop Readiness Resources | Microsoft Partner Training Resources Azure Virtual Desktop Landing Zone Accelerator (LZA) Azure Virtual Desktop Landing Zone Accelerator (LZA) Azure Virtual Desktop Readiness Resources | Microsoft Partner Roadmap and Best Practices AVD Community Blogs AVD Community Blogs Azure Virtual Desktop Readiness Resources | Microsoft Partner Roadmap and Best Practices AVD/Citrix/VMware/Azure Stack HCI Bill of Materials AVD/Citrix/VMware/Azure Stack HCI Bill of Materials Azure Virtual Desktop Readiness Resources | Microsoft Partner Roadmap and Best Practices AVD Level 300 Customer/Partner Deck AVD Level 300 Customer/Partner Deck Shown below are the assessment's questions and how they were answered. Show all original responses available for each question. Retail Readiness Resources Messaging and Use Cases Microsoft Cloud for Retail Partner Messaging Framework Microsoft Cloud for Retail through-partner AI Narrative Microsoft Retail Industry Priority Scenarios Microsoft Cloud for Retail Reference architectures Training Resources Get started with Microsoft Cloud for Retail Self-Paced training Get started with Store Operations Assist in Microsoft Cloud for Retail Self-Paced training Discover Microsoft AI for leaders in retail Self-Paced Training Get started with Smart Store Analytics in Microsoft Cloud for Retail Self-Paced Training Integrate Store Operations Assist with Microsoft Teams Self-Paced Training Marketplace Offer Development Resources Marketplace Training and Support Resources Sell Through the Commercial Marketplace Microsoft Commercial Marketplace Publisher FAQ Mastering the Marketplace: Office Hours Retail Cosell Acceleration Resources Go-To-Market Assets & Recommended Seller Training Retail Partner Industry Sales Kits Microsoft Cloud for Retail Partner Assets Recommended Sellers Training: Get started with Microsoft Cloud for Retail Your overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-1 Critical: 0 to 1 MODERATE 1-2 Moderate: 1 to 2 EXCELLENT 2-4 Excellent: 2 to 4 Your result: 4/4 4 out of 4 Categories that influenced your results Retail Readiness Resources EXCELLENT Marketplace Offer Development Resources EXCELLENT Retail Cosell Acceleration Resources EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. Microsoft Cloud for Retail Adoption Guide | Microsoft Partners - Mar 4, 2025 - 11:59:59 AM Your overall results Excellent '4/4' Retail Readiness Resources Excellent '4/5' Marketplace Offer Development Resources Excellent '3/3' Retail Cosell Acceleration Resources Excellent '3/3' https://learn.microsoft.com Category Link-Text Link Priority ReportingCategory ReportingSubcategory Weight Context CompleteY/N Retail Readiness Resources Microsoft Cloud for Retail Partner Messaging Framework https://assetsprod.microsoft.com/mpn/en-us/microsoft-cloud-for-retail-through-partner-messaging-framework.docx High 0 N Retail Readiness Resources Microsoft Cloud for Retail through-partner AI Narrative https://assetsprod.microsoft.com/mpn/en-us/microsoft-cloud-for-retail-through-partner-ai-narrative.pptx High 0 N Retail Readiness Resources Microsoft Retail Industry Priority Scenarios https://learn.microsoft.com/en-us/azure/cloud-adoption-framework/industry/retail/industry-priority-scenarios High 0 N Retail Readiness Resources Overview of Microsoft Cloud for Retail reference architectures https://learn.microsoft.com/en-us/industry/retail/architecture/overview High 0 N Retail Readiness Resources Get started with Microsoft Cloud for Retail Self-Paced training https://learn.microsoft.com/en-us/training/paths/get-started-retail/ High 0 N Retail Readiness Resources Get started with Store Operations Assist in Microsoft Cloud for Retail Self-Paced Training https://learn.microsoft.com/en-us/training/paths/get-started-store-operations-assist/?source=recommendations High 0 N Retail Readiness Resources Discover Microsoft AI for leaders in retail Self-Paced Training https://learn.microsoft.com/en-us/training/paths/discover-microsoft-ai-leaders-retail/ High 0 N Retail Readiness Resources Get started with Smart Store Analytics in Microsoft Cloud for Retail Self-Paced Training https://learn.microsoft.com/en-us/training/paths/get-started-smart-store-analytics/ High 0 N Retail Readiness Resources Integrate Store Operations Assist with Microsoft Teams Self-Paced Training https://learn.microsoft.com/en-us/training/paths/retail-store-operations-assist-teams/ High 0 N Marketplace Offer Development Resources Sell Through the Commercial Marketplace https://learn.microsoft.com/en-us/training/paths/sell-through-commercial-marketplace/ High 0 N Marketplace Offer Development Resources Microsoft Commercial Marketplace Publisher FAQ https://learn.microsoft.com/en-us/partner-center/marketplace/marketplace-faq-publisher-guide High 0 N Marketplace Offer Development Resources Mastering the Marketplace: Office Hours https://aka.ms/MTMofficehours High 0 N Retail Cosell Acceleration Resources Retail Partner Industry Sales Kits https://partner.microsoft.com/en-us/asset/collection/retail-ip-partner-industry-sales-kit#/ High 0 N Retail Cosell Acceleration Resources Microsoft Cloud for Retail Partner Assets https://partner.microsoft.com/en-us/asset/collection/microsoft-cloud-retail-partner-assets#/ High 0 N Retail Cosell Acceleration Resources Recommended Sellers Training: Get started with Microsoft Cloud for Retail https://learn.microsoft.com/en-us/training/paths/get-started-retail/ High 0 N ----------- Shown below are the assessment's questions and how they were answered. Show all original responses available for each question. Sustainability Readiness Resources Opportunity and Use Cases This is AI … for Sustainability Microsoft Cloud for Sustainability: ESG and the Future of Business Sustainability Readiness Resources Training Resources Microsoft Cloud for Sustainability Training Collection Pre-sales licenses for Sustainability Manager sandbox Environments for Microsoft Partners Fabric Technical Resources Microsoft Cloud for Sustainability Technical Summit Roadmap and Best Practices Well-Architected for Microsoft Cloud for Sustainability What's new in Microsoft Cloud for Sustainability overview Marketplace Training and Support Resources Sell Through the Commercial Marketplace Microsoft Commercial Marketplace Publisher FAQ Mastering the Marketplace: Office Hours Your overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-1 Critical: 0 to 1 MODERATE 1-2 Moderate: 1 to 2 EXCELLENT 2-3 Excellent: 2 to 3 Your result: 3/3 3 out of 3 Categories that influenced your results Sustainability Readiness Resources EXCELLENT Marketplace Offer Development Resources EXCELLENT Sustainability Cosell Acceleration Resources EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. Microsoft Cloud for Sustainability Adoption Guide | Microsoft Partners - Mar 4, 2025 - 12:03:23 PM Your overall results Excellent '3/3' Sustainability Readiness Resources Excellent '3/4' Marketplace Offer Development Resources Excellent '3/3' Sustainability Cosell Acceleration Resources Excellent '2/2' Category Link-Text Link Priority ReportingCategory ReportingSubcategory Weight Context CompleteY/N Sustainability Readiness Resources This is AI … for Sustainability https://info.microsoft.com/ww-landing-this-is-AI-for-sustainability.html?ocid=cmmopf4zodtb High 0 N Sustainability Readiness Resources Microsoft Cloud for Sustainability: ESG and the Future of Business https://www.linkedin.com/learning/microsoft-cloud-for-sustainability-esg-and-the-future-of-business High 0 N Sustainability Readiness Resources Microsoft Cloud for Sustainability Training Collection https://aka.ms/mcfstraininggaths High 0 N Sustainability Readiness Resources Pre-sales licenses for Sustainability Manager sandbox Environments https://experience.dynamics.com/requestlicense/ High 0 N Sustainability Readiness Resources Well-Architected for Microsoft Cloud for Sustainability https://learn.microsoft.com/en-us/industry/well-architected/sustainability/ High 0 N Sustainability Readiness Resources Roadmap: What's new in Microsoft Cloud for Sustainability overview https://learn.microsoft.com/en-us/industry/sustainability/whats-new High 0 N Sustainability Readiness Resources Fabric Technical Resources https://learn.microsoft.com/en-us/credentials/certifications/fabric-analytics-engineer-associate/?practice-assessment-type=certification High 0 N Sustainability Readiness Resources Microsoft Cloud for Sustainability Technical Summit https://aka.ms/mcfstechsummit High 0 N Marketplace Offer Development Resources Sell Through the Commercial Marketplace https://learn.microsoft.com/en-us/training/paths/sell-through-commercial-marketplace/ High 0 N Marketplace Offer Development Resources Microsoft Commercial Marketplace Publisher FAQ https://learn.microsoft.com/en-us/partner-center/marketplace/marketplace-faq-publisher-guide High 0 N Marketplace Offer Development Resources Mastering the Marketplace: Office Hours https://aka.ms/MTMofficehours High 0 N Sustainability Cosell Acceleration Resources Sustainability Marketing Campaigns https://partner.microsoft.com/en-us/asset/collection/sustainability-marketing-campaigns#/ High 0 N Sustainability Cosell Acceleration Resources Recommended Training for Sellers: Get started with Microsoft Cloud for Sustainability https://learn.microsoft.com/en-us/training/paths/get-started-sustainability/ High 0 N ----------- Category Question Answers Selected Answer Note Sustainability Readiness Resources Opportunity and Use Cases This is AI … for Sustainability This is AI … for Sustainability Sustainability Readiness Resources Opportunity and Use Cases Microsoft Cloud for Sustainability: ESG and the Future of Business Microsoft Cloud for Sustainability: ESG and the Future of Business Sustainability Readiness Resources Training Resources Microsoft Cloud for Sustainability Training Collection Microsoft Cloud for Sustainability Training Collection Sustainability Readiness Resources Training Resources Pre-sales licenses for Sustainability Manager sandbox Environments for Microsoft Partners Pre-sales licenses for Sustainability Manager sandbox Environments for Microsoft Partners Sustainability Readiness Resources Fabric Technical Resources Fabric Technical Resources Sustainability Readiness Resources Microsoft Cloud for Sustainability Technical Summit Microsoft Cloud for Sustainability Technical Summit Sustainability Readiness Resources Roadmap and Best Practices Well-Architected for Microsoft Cloud for Sustainability Well-Architected for Microsoft Cloud for Sustainability Sustainability Readiness Resources Roadmap and Best Practices What's new in Microsoft Cloud for Sustainability overview What's new in Microsoft Cloud for Sustainability overview Marketplace Offer Development Resources Marketplace Training and Support Resources Sell Through the Commercial Marketplace Sell Through the Commercial Marketplace Marketplace Offer Development Resources Marketplace Training and Support Resources Microsoft Commercial Marketplace Publisher FAQ Microsoft Commercial Marketplace Publisher FAQ Marketplace Offer Development Resources Marketplace Training and Support Resources Mastering the Marketplace: Office Hours Mastering the Marketplace: Office Hours Sustainability Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training Sustainability Marketing Campaigns Sustainability Marketing Campaigns Sustainability Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training Recommended Sellers Training: Get started with Microsoft Cloud for Sustainability Recommended Sellers Training: Get started with Microsoft Cloud for Sustainability Click on any field below to edit it Page Title "experimental career Page URL " https://archive.org/details/career-experimental-security-isc-microsoft-talk-brigh Description " career experimental Subject Tags " engineering Creator tshingombe Date 2025-03-03 Collection " Community texts Text Item No Language English License Creative Commons Attribution-NonCommercial-ShareAlike More Options Add additional metadata ... (remove) Drag and Drop More Files Here or Name Size x Subscriptions.csv 105 bytes Subscriptions(1).csv 105 bytes _Microsoft_Cloud_for_Retail_Adoption_Guide_Microsoft_Partners_Mar_4_2025_11_59_59_AM.csv 6.1 KB _Azure_Virtual_Desktop_Microsoft_Partner_Mar_4_2025_11_55_56_AM.csv 3.3 KB _Microsoft_Cloud_for_Sustainability_Adoption_Guide_Microsoft_Partners_Mar_4_2025_12_03_23_PM.csv 5.1 KB main.pdf 347 KB cpp-get-started-msvc-170.pdf 7.3 MB cpp-standard-library-msvc-170.pdf 107 MB isc tshingombe exam ims,, Access Control and Identity Management.docx 1.2 MB RF5_LT5_captions_NEW.vtt 15 KB cpp-build-msvc-170.pdf 34 MB Proposal of thesis content 2 final research.pdf 2.0 MB workplace experimental isc report thesis aiu,,eaton microsoft eskom city power.pdf 22 MB Gmail - ISC2 Security Congress 2025_ Call for Presentations Feedback tshingombe.pdf 2.6 MB brightalk-viewing-certificate-comment-créer-du-contenu-de-qualité-et-gagner-du-temps-avec-semrush.pdf 351 KB experimental2 career thesis tlantic office pc lab(1).docx 2.9 MB CISSP-ISSMP-Exam-Outline-November-2022-English.pdf 272 KB CISSP-ISSMP-Exam-Outline-October-2020-English.pdf 416 KB CISSP-ISSAP-Exam-Outline-October-2020-English.pdf 257 KB brighttalk-viewing-certificate-how-intel-are-driving-ai-innovation-at-th Skip to main content Learn Assessments 1.Learn 2.Assessments 3.Browse Recommendations for your workload Actionable items to consider implementing to improve your workload across the five pillars of the Microsoft Azure Well-Architected Framework. Your overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-33 Critical: 0 to 33 MODERATE 33-67 Moderate: 33 to 67 EXCELLENT 67-100 Excellent: 67 to 100 Your result: 99/100 99 out of 100 Categories that influenced your results Azure Databricks: Performance Efficiency EXCELLENT Data Explorer: Reliability EXCELLENT Azure Databricks: Operational Excellence EXCELLENT Azure Databricks: Cost Optimization EXCELLENT Azure Databricks: Security EXCELLENT Azure Databricks: Reliability EXCELLENT ADLS Gen2: Performance Efficiency EXCELLENT Analysis Services: Performance Efficiency EXCELLENT Analysis Services: Operational Excellence EXCELLENT Analysis Services: Cost Optimization EXCELLENT Analysis Services: Reliability EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. Improve your results Our recommendations for improving your results are organized by category below. Azure Databricks: Performance Efficiency EXCELLENT 1 recommended action Data Explorer: Reliability EXCELLENT 2 recommended actions Azure Databricks: Operational Excellence EXCELLENT 0 recommended actions Azure Databricks: Cost Optimization EXCELLENT 0 recommended actions Azure Databricks: Security EXCELLENT 0 recommended actions Azure Databricks: Reliability EXCELLENT 1 recommended action ADLS Gen2: Performance Efficiency EXCELLENT 0 recommended actions Analysis Services: Performance Efficiency EXCELLENT 0 recommended actions Analysis Services: Operational Excellence EXCELLENT 0 recommended actions Analysis Services: Security EXCELLENT 0 recommended actions Analysis Services: Reliability EXCELLENT 0 recommended actions Previous Versions Blog Contribute Privacy Terms of Use Trademarks © Microsoft 2025 Skip to main content Learn Assessments 1.Learn 2.Assessments 3.Browse Recommendations for your workload Actionable items to consider implementing to improve your workload across the five pillars of the Microsoft Azure Well-Architected Framework. Shown below are the assessment's questions and how they were answered. Show all original responses available for each question. WAF analytics service selection Which analytics service(s) are you using? Azure Analysis Services Azure Data Explorer Azure Databricks Azure Data Lake Storage Gen2 What pillars would you like to evaluate? Reliability Cost Optimization Operational Excellence Performance Efficiency Security Analysis Services: Reliability What reliability targets and metrics have you defined for your application? Azure Analysis Services RPO (Recovery Point Objective) and RTO (Recovery Time Objective) targets have been defined for the application and/or key scenarios. Availability SLAs (Service Level Agreements) have been defined for the solution and considered while architecting the solution. Composite SLA (including Azure Analysis Services) has been defined for the service and considered while architecting the solution. None of the above. How have you ensured that your application architecture is resilient to failures? Backup databases from primary server can be restored on redundant servers. An alias is used for the primary server to avoid having to change the connection strings on reporting clients. The database can be restored using SSMS or PowerShell using backups located in a storage account configured for the server. We use asynchronous refresh with the REST API to prevent the need for long-running HTTP connections, auto retries, and batched commits. None of the above. How have you ensured required capacity and services are available in targeted regions? We use the Azure Analysis Services resource and object limits as part of the resource governance mechanisms to enforce these limits. We verify that the Azure Analysis Services product is available in the target region or in case the target region is not the paired region. We verify that the resource governance requirements for the data stored in the data tier (HIPAA, PCI, etc.) None of the above. How are you handling disaster recovery for this workload? We consider the incidents we want to be protected from when choosing the right redundancy options, and build the backup and disaster recovery plan accordingly: local outage, regional disaster, capacity limitations, and so on. We deploy models to redundant servers in other regions. We complete periodic disaster recovery exercises to ensure the procedure works as planned. We verify end-to-end system performance after failover occurs. None of the above. How do you monitor and measure workload health? We use the available metrics, logs, and diagnostics with Azure Monitor. We use Azure Monitor metric alerts with dynamic thresholds detection. We use Azure Resource Health events to alert on resource health events. We use Azure Service Health events to alert on applicable service-level events (service issue, planned maintenance, health advisories, and security advisory). None of the above. Analysis Services: Security What design considerations did you make in your workload with regard to security? We identify and classify business-critical datasets that might adversely affect operations if they're compromised or become unavailable. We list and document security requirements for the Azure Analysis Services instance. We limit access by following the principle of least privilege, protecting data, and monitoring activities offered by Azure Analysis Services. We define and test operational processes for incident response. We review data compliance requirements and choose the appropriate regulatory compliance controls for the data. None of the above. What considerations for compliance and governance do you need to take? We use Azure policies to enforce security, compliance, and organizational standards. We activate diagnostic logs and store them in a log analytics workspace. None of the above. How are you managing encryption for this workload? We rotate the storage key by specifying a key expiration period. We compress and encrypt tabular model backups. None of the above. How are you managing permissions for this workload? User identities are registered within the Microsoft Entra tenant of the subscription. We use Azure Analysis Services role-based access control (RBAC). We use object-level security, which includes table-level security and column-level security. We implement row-level security as part of tabular model roles. None of the above. How have you secured the network of your workload? We configured a server firewall to filter the inbound traffic. We use gateways for on-premises data sources. We use gateways for data sources on Azure Virtual Networks. We use DirectQuery mode, where only metadata is stored. None of the above. Analysis Services: Cost Optimization What actions are you taking to optimize cloud costs? We're getting familiar with Analysis Services pricing, in particular, with elements that drive the price calculation: QPUs, memory (GB), presence of SLA, scale-out instances, tier, uptime, region. We use the Cost Management and Billing tools to analyse and manage costs. Our choice of region in which to deploy the instance is driven by the data source's location, the users' location, the availability of the SKU and of the query replica feature (if it's planned to be used), and the price. We choose the right tier and plan for the instance. We use the right upgrade plan that will allow for more query processing units and more cache capacity. We pause the server when not in use, and resume when needed to only pay for what is used. As an existing Power BI Premium Capacity user, we evaluate the use of Power BI Premium that embeds an Analysis Services instance instead of a standalone Azure Analysis Services server. None of the above. How is your organization modeling cloud costs? We use the cost control feature to set the budget as part of Cost Management for Azure Analysis Services. We lower costs by pausing or scaling the instance to meet performance demands. None of the above. How are you monitoring your costs? We use the cost analysis feature of Azure Cost Management to monitor costs and create budgets. None of the above. Analysis Services: Operational Excellence How are you designing your applications to take into account DevOps? We use source-control integration as the first step in building a continuous integration and deployment pipeline. We use continuous integration and deployment for Azure Analysis Services, and build continuous integration and deployment pipeline for data models. None of the above. How are you managing the configuration of your workload? We automate creation of Azure Analysis Services instances with ARM templates, PowerShell scripts, or Bicep files. We use Dynamic Management Views (DMVs) in Azure Analysis Services to monitor server instances. We monitor server metrics provided by Azure Monitor (memory, CPU usage, number of client connections, query resource consumption, etc.). We enable diagnostic logging for Azure Analysis Services to monitor and send logs to Azure storage, stream them to Azure Event Hubs, or export them to Azure Monitor logs. We add resource health alerts for metrics such as memory usage, memory limit High, and memory limit Hard. None of the above. What operational considerations are you making regarding the deployment of your workload? We're becoming familiar with Azure Analysis Services resource and object limits to learn what happens when those resource limits are hit or exceeded, and describe the resource governance mechanisms used to enforce these limits. No routine and manual operational changes are performed outside of IaC (Infrastructure as Code) to prevent configuration drift by enforcing consistency representing desired environment states. Critical test environments have 1:1 parity with the production environment. None of the above. What processes and procedures have you adopted to optimize workload operability? Specific methodologies, like DevOps, are used to structure the development and operations process. We leverage central Azure monitoring tools like Azure Monitor. Data analysts, data engineers, development teams, and the operations team collaborate to resolve production issues that are clearly defined and well understood. Operational shortcomings and failures are analyzed, post-mortems are performed and used to improve and refine operational procedures. There are tools or processes in place, such as Microsoft Entra Privileged Identity Management, to grant access to critical instances on a just-in-time basis. Azure Resource Tags are used to enrich our AAS instance with operational metadata. There are tools and processes, like Azure Policy, in place to govern available services, enforce mandatory operational functionality and ensure compliance. None of the above. How are you monitoring your resources? We use Azure Monitor to perform more in-depth diagnostics, track performance, and identify trends using the Azure Analysis Services instance. We use Azure Diagnostics to offload Platform logs. We use Extended Events. We use Dynamic Management Views (DMVs). Analysis Services: Performance Efficiency How are you designing your workload to scale? We maintain a healthy workload by automating the scaling of the Azure Analysis Services instances. We use read-only replicas scale-out to have queries return consistent data while processing data. We separate the processing server from the query pool to ensure that client queries aren't affected by processing operations. None of the above. How are you handling user load? We create a query pool with up to seven additional query replicas (eight total, including the server). We simplify the query or its calculations if the query is too memory intensive. How are you ensuring that you have sufficient memory? We monitor metrics to not exceed available server resource memory. We monitor the memory usage broken out by database. None of the above. How are you managing your data to handle scale? We use partitioning to take advantage of incremental loads. We refresh (process) in-memory models to update cached data from data sources. We keep the data model as simple as possible by removing unneeded columns and keeping the size to the minimum, paying attention to the data types. None of the above. How are you monitoring to ensure the workload is scaling appropriately? With Azure service principal support, we perform unattended refresh operations using PowerShell, TOM, TMSL, or REST to make sure our model data is always up to date. We implement asynchronous refresh with the REST API to mitigate long-running operations. None of the above. Data Factory: Reliability Data Factory: Security Data Factory: Cost Optimization Data Factory: Operational Excellence Data Factory: Performance Efficiency Azure Databricks: Reliability How do you implement reliability Best Practices? We deploy workspaces in multiple subscriptions based on service limits, including Databricks workspace limits and Azure subscription limits. We leverage clusters pools with TTL=60 min, or interactive clusters for job-based scenarios where we expect to spin up or down quickly. We stagger job-based clusters in the same workspace for scenarios requiring quick spin up and down of job clusters at less than 5 minutes as the recommended interval. We use Cluster Scoped Init scripts rather than global or named scripts. We ensure that we've configured an appropriate level of data redundancy for our use case. None of the above. How do you implement disaster recovery scenarios? We disable RA-GRS stores in development subscriptions to reduce cost. We use RA-GRS storage accounts only when required to meet disaster planning. We enable soft delete, snapshot, and point in time recovery (PITR) for storage. We perform daily backups of Databricks configuration. We use the cluster log delivery feature to manage logs. Azure Databricks: Security How do you implement security Best Practices? We store any production data in default Azure Databricks file system (DBFS) folders. We deploy the Databricks workspace in our virtual network. We review and plan to implement controls in Microsoft Blueprints for HiTrust / HIPAA and PCI/DSS. We have a process in place to periodically regenerate our account keys. We implement a security development lifecycle and threat model to assess risks in our application. We enable advanced threat protection for storage. How do you implement authentication controls? We enable access control lists to configure permissions at the workspace, clusters, pools, jobs, and data tables. We use credential passthrough to authenticate automatically. We use Azure Key Vault (AKV) to store secrets, including credentials. We enable customer manage keys (CMK) for notebooks and root Databricks File System (DBFS). We enable Oauth authentication. How do you implement encryption on your clusters? We encrypt traffic between clusters and worker nodes. We set up a minimum transport layer security (TLS) version for all storage accounts to TLS 1.2. We limit shared access signature (third-party tools) tokens to HTTPS connections only. None of the above. How do you implement security at the networking level? We enable IP access lists to restrict access to certain IP addresses. We limit private IP addresses. We leverage Azure Private Endpoint. We leverage No Public IP (NPIP). We safelist service principals' names and personal access tokens. We enable virtual network (Vnet) injection. None of the above. How do you audit and monitor your Databricks platform for security? We enable audit logging. We ingest log data in a security information and event manager (SIEM) for security monitoring. We review and reconcile user access. Azure Databricks: Cost Optimization How do you implement cost optimization Best Practices? Users can share autoscaling clusters rather than each user having to create a separate cluster. We leverage the right SKU for the scenario, that is, Jobs Compute for data engineering and Batch ELT workload with single Jobs Compute cluster. We use chargeback scenarios. We review file formats and compute and network and identify areas for cost optimization. We regularly use the delta optimizer to merge small files into larger files. None of the above. How do you implement cost savings? We pre-purchase commit units and reserve VM instances when possible. We choose Azure regions that offer the lowest cost while meeting performance requirements. None of the above. How do you monitor Azure Databricks costs? We monitor costs of clusters using the cost analysis report. We set up budget alerts to monitor costs. We use Databricks Overwatch. None of the above. Azure Databricks: Operational Excellence How do you implement operational Best Practices? We do regular performance, scalability, and stress testing. We build a process to review Azure Advisor and Azure Security Center recommendations on a regular cadence. We review and address platform changes from the release notes. We split workspaces for Dev, QA, and Production. We use automated clusters for production jobs instead of interactive clusters. We run autoscaling clusters when possible. We optimize and curate delta tables (silver tables). We review the continuous integration and continuous deployment (CI/CD) automation framework. We run monthly log reviews to validate environment health. We terminate and rebuild clusters on a frequent basis to ensure Databricks clusters are patched by Microsoft. How do you monitor your Databricks platform for operations? We enable logging and alerting for all components in the Databricks platform. We use dashboards to visualize logs. We set up any cluster activity monitoring. We enable storage account logging. We put a single point of log aggregation in place. We use Network Watcher to collect and Monitor network activity. We ensure that all application-level monitoring is enabled. We use a single pane of glass with telemetry using Log Analytics logs to EventHub for consumption by other systems. We consider ingesting selected logs from Azure storage accounts to Azure Monitor. We monitor for 500 errors by Databricks, Blob storage, or other HTTP endpoints. We implement cluster secure management. What components of your Azure environment do you monitor as part of your operations practice? We use approved time synchronization sources. We configure central security log management. We enable audit logging for Azure resources. We collect security logs from operating systems. We configure security log storage retention. We monitor and review logs. We enable alerts for anomalous activities. We centralize anti-malware logging. We enable DNS query logging. We enable command-line audit logging. Azure Databricks: Performance Efficiency How do you implement performance Best Practices? We choose the correct cluster size by doing iterative performance testing. We regularly conduct rigorous quality and unit testing to validate performance that meets requirements. We leverage the auto-scaling feature with auto-terminate. We turn shuffle off for optimal performance. We check for data skew. We ensure that the file size and format are homogeneous. We consistently use DataFrame API and SparkSQL. We avoid user-defined functions (UDFs) , especially in Python or R. We consider and test repartitioning if we need to join large tables. We ensure Azure limits are increased, for example, Public IP limits and so on. How do you optimize performance efficiency? We reorder skew joins. We optimize for performance with Delta Lake format to get the best price to performance ratio. We partition our data. We check for large shuffle joins and try replacing them with broadcasts. We use Delta Lake with Z-order and optimize the latest Databricks Runtime (DBR) to get the best performance. We use Parquet file format. We use Delta-Cache. How do you test performance efficiency on the Azure Databricks clusters? We run a proof of concept to determine how often to execute based on data ingestion and query patterns. We engage with Azure Engineers to ensure that capacity can be handled in the backend and limits get increased. We engage with the networking team during testing. We ensure throttling is not hit by setting up Azure Data Lake Storage Gen 2 limits. We review all Azure and Databricks limits. We develop a medium-sized cluster of 2-8 nodes, with VMs matched to the workload class, as explained earlier. We run end to end tests on larger representative data while measuring CPU, memory, and I/O used by the cluster at an aggregate level. We optimize the cluster to remove bottlenecks. How do you monitor your Databricks platform for performance efficiency? We troubleshoot performance bottlenecks by using dashboards to identify job and stage latency and streaming throughput. We validate whether upstream components can sustain the load required to pass through them. We run scheduled optimization on delta tables. We tune shuffle for optimal performance. We use autoscaling methodologies whenever possible. We partition our data following Best Practices. None of the above. How do you support interactive analytics using shared high-concurrency clusters? We deploy a shared cluster instead of letting each user create their cluster. We create the shared cluster in High Concurrency mode instead of Standard mode. We configure security on the shared high concurrency cluster. None of the above. Data Explorer: Reliability What reliability targets and metrics have you defined for your application? Ensure that the average CPU is running at 80% capacity or less and cache utilization is 100%. Use Resource Health to monitor the state of Azure Data Explorer. How have you ensured that your application architecture is resilient to failures? This question was left unanswered How are you handling disaster recovery for this workload? This question was left unanswered How do you monitor and measure application health? This question was left unanswered Data Explorer: Security What action are you taking to meet your compliance and governance requirements? This question was left unanswered How are you protecting data for this workload? This question was left unanswered How are you managing identity for this workload? This question was left unanswered How do you keep your Azure Data Explorer cluster from being exposed to the internet? This question was left unanswered Data Explorer: Cost optimization What actions are you taking to optimize cloud costs? This question was left

unanswered How do you ensure that cloud resources are appropriately provisioned? This question was left unanswered How is your organization modeling cloud costs? This question was left unanswered How do you manage the storage footprint of your digital assets? This question was left unanswered How are you monitoring your costs? This question was left unanswered What tradeoffs have you made to optimize for cost? This question was left unanswered Data Explorer: Operational excellence How are you designing your applications to take DevOps into account? This question was left unanswered How are you managing the configuration of your workload? This question was left unanswered What considerations are you making around the deployment of your infrastructure? This question was left unanswered Are you using best practices for Kusto queries? This question was left unanswered How are you monitoring your deployments and workload? This question was left unanswered Data Explorer: Performance efficiency How are you designing your workload to scale? This question was left unanswered How do you optimize Azure Data Explorer workloads for performance? This question was left unanswered How are you ensuring that you have sufficient capacity? This question was left unanswered How are you monitoring to ensure the workload is scaling appropriately? This question was left unanswered Synapse: Reliability What reliability targets and metrics have you defined for your application? This question was left unanswered How have you ensured that your application architecture is resilient to failures? This question was left unanswered How have you ensured required capacity and services are available in targeted regions? This question was left unanswered How are you handling disaster recovery for this workload? This question was left unanswered What decisions have been taken to ensure the application platform meets your reliability requirements? This question was left unanswered How does your application logic handle exceptions and errors? This question was left unanswered What decisions have been taken to ensure networking and connectivity meets your reliability requirements? This question was left unanswered What reliability allowances for scalability and performance have you made? This question was left unanswered What reliability allowances for security have you made? This question was left unanswered What reliability allowances for operations have you made? This question was left unanswered How do you test the application to ensure it is fault tolerant? This question was left unanswered How do you monitor and measure application health? This question was left unanswered Synapse: Security What design considerations did you make in your workload in regards to security? This question was left unanswered What considerations for compliance and governance do you need to take? This question was left unanswered How are you managing encryption for this workload? This question was left unanswered How are you managing identity for this workload? This question was left unanswered How have you secured the network of your workload? This question was left unanswered What tradeoffs do you need to make to meet your security goals? This question was left unanswered How are you ensuring your critical accounts are protected? This question was left unanswered Synapse: Cost Optimization What actions are you taking to optimize cloud costs? This question was left unanswered How do you ensure that cloud resources are appropriately provisioned? This question was left unanswered How is your organization modeling cloud costs? This question was left unanswered How do you manage the storage footprint of your digital assets? This question was left unanswered How are you monitoring your costs? This question was left unanswered What trade-offs have you made to optimize for cost? This question was left unanswered Synapse: Operational Excellence How are you designing your applications to take into account DevOps? This question was left unanswered How are you managing the configuration of your workload? This question was left unanswered What considerations are you making around the deployment of your infrastructure? This question was left unanswered How is development done on this workload? This question was left unanswered How are you monitoring your deployments and workload? This question was left unanswered How are you integrating your workloads? This question was left unanswered Synapse: Performance Efficiency How are you designing your workload to scale? This question was left unanswered How do you optimize Synapse workloads for performance? This question was left unanswered How are you ensuring you have sufficient capacity? This question was left unanswered How are you managing your data to handle scale? This question was left unanswered How are you monitoring to ensure the workload is scaling appropriately? This question was left unanswered ADLS Gen2: Reliability How have you ensured that your application architecture is resilient to failures? This question was left unanswered How have you ensured required capacity and services are available in targeted regions? This question was left unanswered How are you handling disaster recovery for this workload? This question was left unanswered How does your application logic handle exceptions and errors? This question was left unanswered What decisions have been taken to ensure networking and connectivity meets your reliability requirements? This question was left unanswered How do you monitor and measure application health? This question was left unanswered How do you mitigate accidental deletion of your data? This question was left unanswered How do you ensure the availability of your most critical datasets? This question was left unanswered How do you ensure that the data is reliable? This question was left unanswered ADLS Gen2: Security What design considerations did you make in your workload with regard to security? This question was left unanswered What considerations for compliance and governance do you need to take? This question was left unanswered How are you managing encryption for this workload? This question was left unanswered How are you managing identity and authorization for this workload? This question was left unanswered How have you secured the network of your workload? This question was left unanswered What tradeoffs do you need to make to meet your security goals? This question was left unanswered ADLS Gen2: Cost Optimization What actions are you taking to optimize cloud costs? This question was left unanswered How are you monitoring your costs? This question was left unanswered ADLS Gen2: Operational Excellence What tooling do you leverage to monitor your ADLS accounts? This question was left unanswered What considerations are you making around the deployment of your workload? This question was left unanswered How are you integrating your workloads? This question was left unanswered What processes and procedures have you adopted to optimize workload operability? This question was left unanswered Has the data been organized in the data lake to optimize for access, performance, and usability? This question was left unanswered How do you make your data discoverable for users? This question was left unanswered ADLS Gen2: Performance Efficiency How are you designing your workload to scale? This question was left unanswered How do you optimize ADLS workloads for performance? This question was left unanswered How are you managing your data to handle scale? This question was left unanswered How are you ensuring you have sufficient capacity? Review ADLS Gen2 product limits. Monitor ADLS Gen2 resource utilization, query activity, and other metrics that have limitations. None of the above Previous Versions Blog Contribute Privacy Terms of Use Trademarks © Microsoft 2025 our overall results LOW Room to improve. It looks like there are key items needing attention. Review the recommendations to see what actions you can take to improve your results. LOW 0-12 Low: 0 to 12 MODERATE 12-23 Moderate: 12 to 23 EXCELLENT 23-35 Excellent: 23 to 35 Your result: 10/35 10 out of 35 Categories that influenced your results Azure AI Fundamentals LOW Designing and Implementing a Microsoft Azure AI Solution MODERATE You can find out how to improve on individual categories by reviewing the recommendations below in the report. Azure AI Fundamentals Fundamental AI Concepts Azure AI Bot Service Fundamentals of question answering with the Language Service "Create an empty knowledge base, and then manually copy and paste the FAQ entries into it. Fundamentals of Azure AI Document Intelligence Azure AI Vision resource Fundamentals of Azure OpenAI Service Azure OpenAI is Microsoft's version of ChatGPT, a chatbot that uses generative AI models. Designing and Implementing a Microsoft Azure AI Solution Prepare to develop AI solutions on Azure Absolutely correct values based on conditional logic. Secure Azure AI services Switch the app to use the secondary key Deploy Azure AI services in containers Client applications must pass a subscription key to the Azure resource endpoint before using the container. Make recommendations with Azure AI Personalizer In the Azure portal, go to the Monitor page for your AI Personalizer resource, and view the Personalizer average reward. Analyze images Tags Classify images "Image classification (multiclass) Detect, analyze, and recognize faces Location Analyze video Use the Azure AI Vision service to extract key frames from the video. Build a question answering solution Create an empty knowledge base and manually enter the FAQ questions and answers. Build a conversational language understanding model Intents Develop an app with Azure AI Language Sentiment analysis Create a custom text classification solution A multiple label classification project Create a custom named entity extraction solution Recall Translate text with the Azure AI Translator service Detect Create speech-enabled apps with Azure AI services The location and one of the keys Translate speech with the Azure AI Speech service SpeechConfig Create an Azure Cognitive Search solution Add a JSON file that defines an Azure AI Search index to the blob container. Create a custom skill for Azure Cognitive Search Create a custom skill that uses an Azure Machine Learning model to predict the sentiment for a document. Create a knowledge store with Azure Cognitive Search Merge Enrich a search index using Language Studio Conversational language understanding. Implement advanced search features in Azure Cognitive Search ^ Build an Azure Machine Learning custom skill for Azure Cognitive Search Real-time endpoint Maintain an Azure Cognitive Search Solution Create an Azure Cognitive Search service with a Storage Optimized service tier and at least two replicas. Use semantic search to get better search results in Azure Cognitive Search As many results as the BM25 ranking function returns. Improve search results using vector search in Azure Cognitive Search To create a search to match text input. Plan an Azure AI Document Intelligence solution A Composed model. Use prebuilt Azure AI Document Intelligence models Read model. Create a composed Form Recognizer model modelId Generate code with Azure OpenAI Service Increase in efficiency and productivity Generate images with Azure OpenAI Service GPT-35-Turbo Fundamentals of Responsible Generative AI To make a legal case that indemnifies you from responsibility for AI Engineer Skill Assessment - Mar 4, 2025 - 1:05:49 PM Your overall results Low '10/35' Azure AI Fundamentals Low '0/4' Designing and Implementing a Microsoft Azure AI Solution Moderate '10/31' Category Link-Text Link Priority ReportingCategory ReportingSubcategory Weight Context CompleteY/N Note Azure AI Fundamentals https://learn.microsoft.com High 0 N Azure AI Fundamentals Microsoft Azure AI Fundamentals: Computer Vision https://learn.microsoft.com/en-us/training/paths/explore-computer-vision-microsoft-azure/ High 0 N Azure AI Fundamentals Microsoft Azure AI Fundamentals: Natural Language Processing https://learn.microsoft.com/en-us/training/paths/explore-natural-language-processing/ High 0 N Azure AI Fundamentals Microsoft Azure AI Fundamentals: Document Intelligence and Knowledge Mining https://learn.microsoft.com/en-us/training/paths/document-intelligence-knowledge-mining/ High 0 N Azure AI Fundamentals Microsoft Azure AI Fundamentals: Generative AI https://learn.microsoft.com/en-us/training/paths/introduction-generative-ai/ High 0 N Designing and Implementing a Microsoft Azure AI Solution https://learn.microsoft.com High 0 N Designing and Implementing a Microsoft Azure AI Solution Get started with Azure AI Services https://learn.microsoft.com/en-us/training/paths/get-started-azure-ai/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Develop decision support solutions with Azure AI Services https://learn.microsoft.com/en-us/training/paths/develop-decision-support/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Create computer vision solutions with Azure AI Vision https://learn.microsoft.com/en-us/training/paths/create-computer-vision-solutions-azure-ai/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Develop natural language processing solutions with Azure AI Services https://learn.microsoft.com/en-us/training/paths/develop-language-solutions-azure-ai/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Implement knowledge mining with Azure Cognitive Search https://learn.microsoft.com/en-us/training/paths/implement-knowledge-mining-azure-cognitive-search/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Develop solutions with Azure AI Document Intelligence https://learn.microsoft.com/en-us/training/paths/extract-data-from-forms-document-intelligence/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Develop Generative AI solutions with Azure OpenAI Service https://learn.microsoft.com/en-us/training/paths/develop-ai-solutions-azure-openai/ High 0 N ---------- Category Question Answers Selected Answer Note Azure AI Fundamentals Fundamental AI Concepts Azure Machine Learning Azure AI Fundamentals Fundamental AI Concepts Azure AI Bot Service Azure AI Bot Service Azure AI Fundamentals Fundamental AI Concepts Azure AI Language Azure AI Fundamentals Fundamentals of machine learning Regression Azure AI Fundamentals Fundamentals of machine learning Classification Azure AI Fundamentals Fundamentals of machine learning Clustering Azure AI Fundamentals Fundamentals of Azure AI services A multi-service resource that includes all the AI services Azure AI Fundamentals Fundamentals of Azure AI services A single-service resource for each AI service Azure AI Fundamentals Fundamentals of Azure AI services It's not possible to see costs for individual AI services Azure AI Fundamentals Fundamentals of Computer Vision Timestamps in photograph metadata Azure AI Fundamentals Fundamentals of Computer Vision Pixels Azure AI Fundamentals Fundamentals of Computer Vision Image file names Azure AI Fundamentals Fundamentals of Facial Recognition A pair of coordinates for each face, indicating the center of the face Azure AI Fundamentals Fundamentals of Facial Recognition Two pairs of coordinates for each face, indicating the location of the eyes Azure AI Fundamentals Fundamentals of Facial Recognition A set of coordinates for each face, defining a rectangular bounding box around the face Azure AI Fundamentals Fundamentals of optical character recognition Azure AI Vision Azure AI Fundamentals Fundamentals of optical character recognition Azure AI services Azure AI Fundamentals Fundamentals of optical character recognition Azure AI Language Azure AI Fundamentals Fundamentals of Text Analysis with the Language Service Sentiment analysis Azure AI Fundamentals Fundamentals of Text Analysis with the Language Service Key phrase extraction Azure AI Fundamentals Fundamentals of Text Analysis with the Language Service Entity detection Azure AI Fundamentals Fundamentals of question answering with the Language Service "Create an empty knowledge base, and then manually copy and paste the FAQ entries into it. "Create an empty knowledge base, and then manually copy and paste the FAQ entries into it. Azure AI Fundamentals Fundamentals of question answering with the Language Service Import the existing FAQ document into a new knowledge base. Azure AI Fundamentals Fundamentals of question answering with the Language Service Import a pre-defined chit-chat data source. Azure AI Fundamentals Fundamentals of conversational language understanding Azure AI Speech Azure AI Fundamentals Fundamentals of conversational language understanding Azure AI Language Azure AI Fundamentals Fundamentals of conversational language understanding Azure AI services Azure AI Fundamentals Fundamentals of Azure AI Speech Speech Azure AI Fundamentals Fundamentals of Azure AI Speech Language Azure AI Fundamentals Fundamentals of Azure AI Speech Azure AI services Azure AI Fundamentals Fundamentals of Azure AI Document Intelligence Azure AI Vision resource Azure AI Vision resource Azure AI Fundamentals Fundamentals of Azure AI Document Intelligence Azure AI Document Intelligence or Azure AI services resource. Azure AI Fundamentals Fundamentals of Azure AI Document Intelligence Azure AI Language resource. Azure AI Fundamentals Fundamentals of Knowledge Mining with Azure Cognitive Search CSV Azure AI Fundamentals Fundamentals of Knowledge Mining with Azure Cognitive Search SQL Azure AI Fundamentals Fundamentals of Knowledge Mining with Azure Cognitive Search JSON Azure AI Fundamentals Fundamentals of Generative AI Models that only work with one language. Azure AI Fundamentals Fundamentals of Generative AI Models that only work with small amounts of data. Azure AI Fundamentals Fundamentals of Generative AI Models that use deep learning to process and understand natural language on a massive scale. Azure AI Fundamentals Fundamentals of Azure OpenAI Service Azure OpenAI is Microsoft's version of ChatGPT, a chatbot that uses generative AI models. Azure OpenAI is Microsoft's version of ChatGPT, a chatbot that uses generative AI models. Azure AI Fundamentals Fundamentals of Azure OpenAI Service ChatGPT and OpenAI are chatbots that generate natural language, code, and images. Azure OpenAI provides access to these two chatbots. Azure AI Fundamentals Fundamentals of Azure OpenAI Service OpenAI is a research company that developed ChatGPT, a chatbot that uses generative AI models. Azure OpenAI provides access to many of OpenAI's AI models. Azure AI Fundamentals Fundamentals of Responsible Generative AI To make a legal case that indemnifies you from responsibility for harms caused by the solution Azure AI Fundamentals Fundamentals of Responsible Generative AI To document the purpose, expected use, and potential harms for the solution Azure AI Fundamentals Fundamentals of Responsible Generative AI To evaluate the cost of cloud services required to implement your solution Designing and Implementing a Microsoft Azure AI Solution Prepare to develop AI solutions on Azure Absolutely correct values based on conditional logic. Absolutely correct values based on conditional logic. Designing and Implementing a Microsoft Azure AI Solution Prepare to develop AI solutions on Azure Randomly selected values with an equal chance of selection. Designing and Implementing a Microsoft Azure AI Solution Prepare to develop AI solutions on Azure Probabilistic values based on correlations found in training data. Designing and Implementing a Microsoft Azure AI Solution Create and consume Azure AI services The application must specify a valid subscription key for the Azure resource. Designing and Implementing a Microsoft Azure AI Solution Create and consume Azure AI services The user of the application must enter a user name and password associated with the Azure subscription. Designing and Implementing a Microsoft Azure AI Solution Create and consume Azure AI services Access to Azure AI Services is granted to anonymous users by default. Designing and Implementing a Microsoft Azure AI Solution Secure Azure AI services Switch the app to use the secondary key Switch the app to use the secondary key Designing and Implementing a Microsoft Azure AI Solution Secure Azure AI services Change the resource endpoint Designing and Implementing a Microsoft Azure AI Solution Secure Azure AI services Enable a firewall Designing and Implementing a Microsoft Azure AI Solution Monitor Azure AI services Create an alert. Designing and Implementing a Microsoft Azure AI Solution Monitor Azure AI services Configure diagnostic settings. Designing and Implementing a Microsoft Azure AI Solution Monitor Azure AI services Create a dashboard. Designing and Implementing a Microsoft Azure AI Solution Deploy Azure AI services in containers Client applications must pass a subscription key to the Azure resource endpoint before using the container. Client applications must pass a subscription key to the Azure resource endpoint before using the container. Designing and Implementing a Microsoft Azure AI Solution Deploy Azure AI services in containers The container must be able to connect to the Azure resource endpoint to send usage data for billing. Designing and Implementing a Microsoft Azure AI Solution Deploy Azure AI services in containers All data passed from the client application to the container is forwarded to the Azure resource endpoint. Designing and Implementing a Microsoft Azure AI Solution Make recommendations with Azure AI Personalizer In the Azure portal, go to the Monitor page for your AI Personalizer resource, and view the Personalizer average reward. In the Azure portal, go to the Monitor page for your AI Personalizer resource, and view the Personalizer average reward. Designing and Implementing a Microsoft Azure AI Solution Make recommendations with Azure AI Personalizer In the Azure portal, go to the Monitor page for your AI Personalizer resource, and view the Baseline average reward. Designing and Implementing a Microsoft Azure AI Solution Make recommendations with Azure AI Personalizer In the Azure portal, go to the Monitor page for your AI Personalizer resource, and view the Reward achievement ratio. Designing and Implementing a Microsoft Azure AI Solution Analyze images Tags Tags Designing and Implementing a Microsoft Azure AI Solution Analyze images Description Designing and Implementing a Microsoft Azure AI Solution Analyze images Categories Designing and Implementing a Microsoft Azure AI Solution Classify images "Image classification (multiclass) "Image classification (multiclass) Designing and Implementing a Microsoft Azure AI Solution Classify images Image classification (multilabel) Designing and Implementing a Microsoft Azure AI Solution Classify images Object detection Designing and Implementing a Microsoft Azure AI Solution Detect objects in images The location and class of specific classes of object in an image. Designing and Implementing a Microsoft Azure AI Solution Detect objects in images The class of the main subject of an image. Designing and Implementing a Microsoft Azure AI Solution Detect objects in images The file type of an image. Designing and Implementing a Microsoft Azure AI Solution Detect, analyze, and recognize faces Location Location Designing and Implementing a Microsoft Azure AI Solution Detect, analyze, and recognize faces Type of eye-glasses Designing and Implementing a Microsoft Azure AI Solution Detect, analyze, and recognize faces Occlusion Designing and Implementing a Microsoft Azure AI Solution Read Text in Images and Documents with the Azure AI Vision Service Only total content and pages of text. Designing and Implementing a Microsoft Azure AI Solution Read Text in Images and Documents with the Azure AI Vision Service Pages, words and lines of text. Designing and Implementing a Microsoft Azure AI Solution Read Text in Images and Documents with the Azure AI Vision Service Total content, pages, words and lines of text. Designing and Implementing a Microsoft Azure AI Solution Analyze video Use the Azure AI Vision service to extract key frames from the video. Use the Azure AI Vision service to extract key frames from the video. Designing and Implementing a Microsoft Azure AI Solution Analyze video Upload the video to Azure Video Indexer and index it. Designing and Implementing a Microsoft Azure AI Solution Analyze video Store the video file in an Azure blob store container. Designing and Implementing a Microsoft Azure AI Solution Analyze text with Azure AI Language Use the Azure AI Language service to extract key phrases. Designing and Implementing a Microsoft Azure AI Solution Analyze text with Azure AI Language Use the Azure AI Language service to perform sentiment analysis of the comments. Designing and Implementing a Microsoft Azure AI Solution Analyze text with Azure AI Language Use the Azure AI Language service to extract named entities from the comments. Designing and Implementing a Microsoft Azure AI Solution Build a question answering solution Create an empty knowledge base and manually enter the FAQ questions and answers. Create an empty knowledge base and manually enter the FAQ questions and answers. Designing and Implementing a Microsoft Azure AI Solution Build a question answering solution Create a new knowledge base, importing the existing FAQ document. Designing and Implementing a Microsoft Azure AI Solution Build a question answering solution "Create a new knowledge base, selecting only the Professional chit-chat source. Designing and Implementing a Microsoft Azure AI Solution Build a conversational language understanding model Intents Intents Designing and Implementing a Microsoft Azure AI Solution Build a conversational language understanding model Utterances Designing and Implementing a Microsoft Azure AI Solution Build a conversational language understanding model Entities Designing and Implementing a Microsoft Azure AI Solution Develop an app with Azure AI Language Sentiment analysis Sentiment analysis Designing and Implementing a Microsoft Azure AI Solution Develop an app with Azure AI Language Key phrase extraction Designing and Implementing a Microsoft Azure AI Solution Develop an app with Azure AI Language Entity recognition Designing and Implementing a Microsoft Azure AI Solution Create a custom text classification solution A single label classification project Designing and Implementing a Microsoft Azure AI Solution Create a custom text classification solution A multiple label classification project A multiple label classification project Designing and Implementing a Microsoft Azure AI Solution Create a custom text classification solution A varied label classification project Designing and Implementing a Microsoft Azure AI Solution Create a custom named entity extraction solution Recall Recall Designing and Implementing a Microsoft Azure AI Solution Create a custom named entity extraction solution Precision Designing and Implementing a Microsoft Azure AI Solution Create a custom named entity extraction solution F1 score Designing and Implementing a Microsoft Azure AI Solution Translate text with the Azure AI Translator service Detect Detect Designing and Implementing a Microsoft Azure AI Solution Translate text with the Azure AI Translator service Translate Designing and Implementing a Microsoft Azure AI Solution Translate text with the Azure AI Translator service Transliterate Designing and Implementing a Microsoft Azure AI Solution Create speech-enabled apps with Azure AI services The location and one of the keys The location and one of the keys Designing and Implementing a Microsoft Azure AI Solution Create speech-enabled apps with Azure AI services The primary and secondary keys Designing and Implementing a Microsoft Azure AI Solution Create speech-enabled apps with Azure AI services The endpoint and one of the keys Designing and Implementing a Microsoft Azure AI Solution Translate speech with the Azure AI Speech service SpeechConfig SpeechConfig Designing and Implementing a Microsoft Azure AI Solution Translate speech with the Azure AI Speech service SpeechTranslationConfig Designing and Implementing a Microsoft Azure AI Solution Translate speech with the Azure AI Speech service AudioConfig Designing and Implementing a Microsoft Azure AI Solution Create an Azure Cognitive Search solution Add a JSON file that defines an Azure AI Search index to the blob container. Add a JSON file that defines an Azure AI Search index to the blob container. Designing and Implementing a Microsoft Azure AI Solution Create an Azure Cognitive Search solution Enable anonymous access for the blob container. Designing and Implementing a Microsoft Azure AI Solution Create an Azure Cognitive Search solution In an Azure AI Services resource, and add a data source that references the container where the files are stored. Designing and Implementing a Microsoft Azure AI Solution Create a custom skill for Azure Cognitive Search Create a custom skill that uses an Azure Machine Learning model to predict the sentiment for a document. Create a custom skill that uses an Azure Machine Learning model to predict the sentiment for a document. Designing and Implementing a Microsoft Azure AI Solution Create a custom skill for Azure Cognitive Search Create a custom skill that calls the Azure AI Language service to predict the sentiment of each document. Designing and Implementing a Microsoft Azure AI Solution Create a custom skill for Azure Cognitive Search Add the built-in Sentiment skill to the skillset used by the indexer. Designing and Implementing a Microsoft Azure AI Solution Create a knowledge store with Azure Cognitive Search Merge Merge Designing and Implementing a Microsoft Azure AI Solution Create a knowledge store with Azure Cognitive Search Shaper Designing and Implementing a Microsoft Azure AI Solution Create a knowledge store with Azure Cognitive Search Split Designing and Implementing a Microsoft Azure AI Solution Enrich a search index using Language Studio Conversational language understanding. Conversational language understanding. Designing and Implementing a Microsoft Azure AI Solution Enrich a search index using Language Studio Analyze sentiment. Designing and Implementing a Microsoft Azure AI Solution Enrich a search index using Language Studio Custom text classification. Designing and Implementing a Microsoft Azure AI Solution Implement advanced search features in Azure Cognitive Search + Designing and Implementing a Microsoft Azure AI Solution Implement advanced search features in Azure Cognitive Search ^ ^ Designing and Implementing a Microsoft Azure AI Solution Implement advanced search features in Azure Cognitive Search ! Designing and Implementing a Microsoft Azure AI Solution Build an Azure Machine Learning custom skill for Azure Cognitive Search Real-time endpoint Real-time endpoint Designing and Implementing a Microsoft Azure AI Solution Build an Azure Machine Learning custom skill for Azure Cognitive Search Web service Designing and Implementing a Microsoft Azure AI Solution Build an Azure Machine Learning custom skill for Azure Cognitive Search Batch endpoint Designing and Implementing a Microsoft Azure AI Solution Search data outside the Azure platform in Azure Cognitive Search using Azure Data Factory You can only upload one document at a time. Designing and Implementing a Microsoft Azure AI Solution Search data outside the Azure platform in Azure Cognitive Search using Azure Data Factory The JSON can't contain complex data types like arrays. Designing and Implementing a Microsoft Azure AI Solution Search data outside the Azure platform in Azure Cognitive Search using Azure Data Factory You have to define the index in the Azure portal first. Designing and Implementing a Microsoft Azure AI Solution Maintain an Azure Cognitive Search Solution Create an Azure Cognitive Search service with a Storage Optimized service tier and at least two replicas. Create an Azure Cognitive Search service with a Storage Optimized service tier and at least two replicas. Designing and Implementing a Microsoft Azure AI Solution Maintain an Azure Cognitive Search Solution Create an Azure Cognitive Search service with any Standard service tier and at least three replicas. Designing and Implementing a Microsoft Azure AI Solution Maintain an Azure Cognitive Search Solution Create an Azure Cognitive Search service with a High-density service tier and one replica. Designing and Implementing a Microsoft Azure AI Solution Use semantic search to get better search results in Azure Cognitive Search Up to 50. Designing and Implementing a Microsoft Azure AI Solution Use semantic search to get better search results in Azure Cognitive Search As many results as the BM25 ranking function returns. As many results as the BM25 ranking function returns. Designing and Implementing a Microsoft Azure AI Solution Use semantic search to get better search results in Azure Cognitive Search Up to 25. Designing and Implementing a Microsoft Azure AI Solution Improve search results using vector search in Azure Cognitive Search To create a search to match text input. To create a search to match text input. Designing and Implementing a Microsoft Azure AI Solution Improve search results using vector search in Azure Cognitive Search When you need to find matches across different types of data. from a search index. Designing and Implementing a Microsoft Azure AI Solution Improve search results using vector search in Azure Cognitive Search To upload and index a document library. Designing and Implementing a Microsoft Azure AI Solution Plan an Azure AI Document Intelligence solution A Read model. Designing and Implementing a Microsoft Azure AI Solution Plan an Azure AI Document Intelligence solution A Layout model. Designing and Implementing a Microsoft Azure AI Solution Plan an Azure AI Document Intelligence solution A Composed model. A Composed model. Designing and Implementing a Microsoft Azure AI Solution Use prebuilt Azure AI Document Intelligence models Read model. Read model. Designing and Implementing a Microsoft Azure AI Solution Use prebuilt Azure AI Document Intelligence models General document model. Designing and Implementing a Microsoft Azure AI Solution Use prebuilt Azure AI Document Intelligence models ID document model. Designing and Implementing a Microsoft Azure AI Solution Extract data from forms with Azure Document Intelligence Train Model and Get Model Labels Designing and Implementing a Microsoft Azure AI Solution Extract data from forms with Azure Document Intelligence Analyze Invoice and Get Analyze Invoice Result Designing and Implementing a Microsoft Azure AI Solution Extract data from forms with Azure Document Intelligence Create Azure Document Intelligence and Get Analyze Invoice Result Designing and Implementing a Microsoft Azure AI Solution Create a composed Form Recognizer model modelId modelId Designing and Implementing a Microsoft Azure AI Solution Create a composed Form Recognizer model status Designing and Implementing a Microsoft Azure AI Solution Create a composed Form Recognizer model docType Designing and Implementing a Microsoft Azure AI Solution Build an Azure AI Document Intelligence custom skill for Azure Cognitive Search formUrl Designing and Implementing a Microsoft Azure AI Solution Build an Azure AI Document Intelligence custom skill for Azure Cognitive Search recordId Designing and Implementing a Microsoft Azure AI Solution Build an Azure AI Document Intelligence custom skill for Azure Cognitive Search formSasToken Designing and Implementing a Microsoft Azure AI Solution Get started with Azure OpenAI Service text-davinci-003 Designing and Implementing a Microsoft Azure AI Solution Get started with Azure OpenAI Service gpt-35-turbo Designing and Implementing a Microsoft Azure AI Solution Get started with Azure OpenAI Service text-embedding-ada-002 (Version 2) Designing and Implementing a Microsoft Azure AI Solution Build natural language solutions with Azure OpenAI Service Chat, Embedding, and Completion Designing and Implementing a Microsoft Azure AI Solution Build natural language solutions with Azure OpenAI Service Key, Endpoint, and Deployment name Designing and Implementing a Microsoft Azure AI Solution Build natural language solutions with Azure OpenAI Service Summary, Deployment name, and Endpoint Designing and Implementing a Microsoft Azure AI Solution Apply prompt engineering with Azure OpenAI Service By using complex instructions that are difficult to understand Designing and Implementing a Microsoft Azure AI Solution Apply prompt engineering with Azure OpenAI Service By providing clear and descriptive instructions Designing and Implementing a Microsoft Azure AI Solution Apply prompt engineering with Azure OpenAI Service By using vague prompts Designing and Implementing a Microsoft Azure AI Solution Generate code with Azure OpenAI Service Increase in efficiency and productivity Increase in efficiency and productivity Designing and Implementing a Microsoft Azure AI Solution Generate code with Azure OpenAI Service Increase in bugs and readability Designing and Implementing a Microsoft Azure AI Solution Generate code with Azure OpenAI Service Increase in time spent coding Designing and Implementing a Microsoft Azure AI Solution Generate images with Azure OpenAI Service DALL-E Designing and Implementing a Microsoft Azure AI Solution Generate images with Azure OpenAI Service GPT-35-Turbo GPT-35-Turbo Designing and Implementing a Microsoft Azure AI Solution Generate images with Azure OpenAI Service Text-Davinci Designing and Implementing a Microsoft Azure AI Solution Use your own data with Azure OpenAI Service Create their own AI chat models Designing and Implementing a Microsoft Azure AI Solution Use your own data with Azure OpenAI Service Access Azure OpenAI without an approved subscription Designing and Implementing a Microsoft Azure AI Solution Use your own data with Azure OpenAI Service Use supported AI chat models that can reference specific sources of data Designing and Implementing a Microsoft Azure AI Solution Fundamentals of Responsible Generative AI To make a legal case that indemnifies you from responsibility for harms caused by the solution. To make a legal case that indemnifies you from responsibility for harms caused by the solution. Designing and Implementing a Microsoft Azure AI Solution Fundamentals of Responsible Generative AI To document the purpose, expected use, and potential harms for the solution. Designing and Implementing a Microsoft Azure AI Solution Fundamentals of Responsible Generative AI To evaluate the cost of cloud services required to implement your solution. Your overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-33 Critical: 0 to 33 MODERATE 33-67 Moderate: 33 to 67 EXCELLENT 67-100 Excellent: 67 to 100 Your result: 100/100 100 out of 100 Categories that influenced your results Azure Machine Learning: Cost Optimization EXCELLENT Azure Machine Learning: Operational Excellence EXCELLENT Azure Machine Learning: Performance Efficiency EXCELLENT Azure Machine Learning: Reliability EXCELLENT Azure Machine Learning: Security EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. Azure Machine Learning: Cost Optimization What steps are you taking to optimize cloud costs in Azure Machine Learning? We use cost management tools to plan and track costs. We identify and use the right-sized compute for machine learning models. We're considering the use of local compute or remote managed compute for automated machine learning to reduce costs. We optimize our cloud investment with cost management. We use an appropriately sized compute instance and compute cluster for training and inference. None of the above. How does your organization model and monitor cloud costs for Azure Machine Learning? We plan and manage costs for Azure Machine Learning. We utilize cost alerts for Azure Machine Learning. We create and manage Azure budgets. None of the above. What actions do you typically take for cost optimization in Azure Machine Learning? We configure our training clusters to autoscale. We set quotas on our subscription and workspaces. We set termination policies on our training job. We use low-priority virtual machines (VMs). We schedule compute instances to shut down and start up automatically. We use an Azure Reserved VM Instance. We train locally. We parallelize training. We set data retention and deletion policies. We deploy resources to the same region. How do you ensure that you have sufficient capacity? We adhere to Azure Machine Learning subscription limits for compute and pipelines. We review service limits in Azure Machine Learning. We adhere to Azure Machine Learning subscription limits for storage. None of the above. Azure Machine Learning: Operational Excellence How are you managing your machine learning lifecycle through automation using MLOps? We use machine learning pipelines to orchestrate the workflow. We use GitHub Actions with Azure Machine Learning. We use MLFlow to track and manage ML modeling projects. We use the Team Data Science Process for the data science project lifecycle. None of the above. What considerations are you making around the deployment of your infrastructure? We segregate environments into development, test, and production workspaces. We understand the Azure subscription limits that might impact this workload. We use the Azure security baseline for Azure Machine Learning. We set up separate workspaces for each publish environment. None of the above. How is development done on Azure Machine Learning workloads? We use Python SDK or CLI to develop machine learning jobs. We use low-code Azure Machine Learning designer to author experiments. We use the Azure Machine Learning Notebook or Jupyter Notebook to author the experiment. We use Azure Machine Learning automated GUI to author the experiment. We use ONNX and deep learning libraries, such as Tensorflow, PyTorch, Keras, and others. We use Responsible AI in our development practice. None of the above. How do you monitor your Azure Machine Learning deployments? We monitor a deployed model by collecting and evaluating model data. We enable logging in machine learning training runs. We use alert rules and events in our application. We analyze Azure Machine Learning platform metrics and logs from Azure Monitor. None of the above. How do you manage the configuration of Azure Machine Learning deployments? We use code-based (SDK or CLI) definitions of our training jobs. We use code-based definitions of our compute targets. None of the above. How do you test your MLOps infrastructure? We use unit, regression, and integration testing with CI/CD for MLOps. None of the above. Azure Machine Learning: Performance Efficiency How are you designing your Azure Machine Learning training workload to scale? We use data partitioning strategy to run experiments in parallel, if possible. We use autoscaling on clusters, where appropriate. We use Azure Machine Learning pipeline step to process large amounts of data asynchronously and in parallel. None of the above. How are you designing your Azure Machine Learning service to meet performance requirements? We use appropriate compute SKUs and sizes for different machine learning workloads. We use the appropriate compute target types based on your workload requirements and environments. We use datastore and dataset mounts for reusability throughout workload. For unstructured files, we optimize performance by mounting data files to the compute target. We use advanced automated ML options to increase performance/ROI on experiment run time. How do you optimize data processing speeds for Azure Machine Learning workloads? We set up Azure Machine Learning datastores/datasets to connect and access data from various storage services. We use distributed training with Azure Machine Learning, where possible. We use datasets/datastores to improve manageability, performance, and scale when working with data. How do you monitor model performance and lifecycle activities? We leverage Azure Machine Learning monitoring capabilities, such as model run logs and metrics. We enable logging in Azure Machine Learning training runs. We use Azure Monitor to monitor the performance of our model. We leverage the Azure Machine Learning workspace job console to track workload progress. How do you autoscale Azure Machine Learning compute resources to handle performance for training and inference? We leverage Azure Machine Learning capabilities to autoscale the training compute nodes based on our benchmarking. We leverage multinode scaling capabilities for model training. We leverage production-grade model deployment and autoscaling inference using Azure Kubernetes Service cluster. Azure Machine Learning: Reliability What reliability considerations have you defined for your Azure Machine Learning workload? We use a Managed Batch Endpoint for parallel batch processing. We use a Managed Endpoint for scalable, self-managed service. We use Azure Kubernetes Service (AKS) for high-scale production deployments with fast response time. We manage and increase quotas for resources with Azure Machine Learning. None of the above. How have you ensured that your application architecture is resilient to failures? We version and track Azure Machine Learning datasets. We enable logging in machine learning training runs to support handling exceptions and errors. We publish Azure Machine Learning components and environments. None of the above. What decisions have you made to ensure the application platform meets your reliability requirements? We use scaling options for applications in Azure Kubernetes Service (AKS). We use a managed endpoint for scalable deployments. We manage a compute cluster in your Azure Machine Learning workspace. We built a failover plan for business continuity and disaster recovery to respond to failures and disasters. None of the above. How do you monitor and measure both the health of a training run and the health of deployed service? We collect machine learning log files in Application Insights. We version and track Azure Machine Learning datasets. We use native application monitoring. None of the above. What framework do you use to interpret ML models and help train unbiased models? We check trained models for fairness. We perform error analysis for trained models for reliability and safety. We interpret trained models for transparency. We perform causal analysis to understand how data impacts model decisions. None of the above. Azure Machine Learning: Security What design considerations did you make in your workload in regard to security? We use role-based access control (RBAC) to manage access to Azure Machine Learning workspaces. We use Microsoft Entra ID for identity management and authentication of Azure Machine Learning users and processes for Azure Machine Learning resources and workflows. We use MLOps practices for security guidance, model management, deployment, and monitoring with Azure Machine Learning. We use appropriate recommendations for the Azure Machine Learning security baseline to improve security posture. We review and implement appropriate guidelines from Azure Machine Learning best practices for enterprise security. None of the above. What considerations for compliance and governance have you made for your Azure Machine Learning workload? We implemented a security and governance plan in accordance with guidance. We audit and manage Azure Machine Learning using Azure Policy. None of the above. How do you manage encryption for workloads? We use data encryption with Azure Machine Learning. None of the above. How do you manage identity for Azure Machine Learning workloads? When running Azure Machine Learning in Azure Kubernetes Service, we use Microsoft Entra Workload ID with Azure Machine Learning. We use managed identities with Azure Machine Learning for access control. None of the above. How have you secured the network for your workload? We use virtual networks (VNets) to secure an Azure Machine Learning workspace during setup. We use virtual networks (VNets) to secure an Azure Machine Learning training environment. We configured Azure Private Link for Azure Machine Learning to enable private endpoint for inferencing. We secured an Azure Machine Learning inferencing environment with virtual networks (VNets). We use Azure Machine Learning studio in an Azure virtual network (VNet). We use TLS to secure web service through Azure Machine Learning. None of the above. How do you adhere to responsible ML principles in your design? We use practices to protect users' data privacy in machine learning. We work on encrypted data with homomorphic encryption. We model interpretability with Azure Machine Learning. We assess fairness in machine learning models using open-source packages in Azure Machine Learning. We perform causal inference in Azure Machine Learning. None of the above. Your overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-2 Critical: 0 to 2 MODERATE 2-4 Moderate: 2 to 4 EXCELLENT 4-6 Excellent: 4 to 6 Your result: 6/6 6 out of 6 Categories that influenced your results AVS | Readiness Resources EXCELLENT AVS | Marketplace Offer Development Resources EXCELLENT AVS | Specialization Resources EXCELLENT AVS | Cosell Acceleration Resources EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. AVS | Readiness Resources Opportunity and Use Cases Migrating VMware vSphere workloads to Azure VMware Solution Extending hybrid and multi-cloud agility High availability and disaster recovery for VMware workloads Desktop virtualization Azure Migrate and Modernize and Azure Innovate Training Resources Introduction Learning Path Learning Resources Overview Video AVS Academy VMware TechZone VMware for Azure VMware Solution Master Specialist Exam AVS LAB Automation VMware AVS Hands-on Labs AVS Workshop Lab Guide Deployment Guidance Landing Zone Accelerator Landing Zone Assessment Review Landing Zone Assessment Network Design Guide Deployment Checklist Azure Well-Architected Assessment for AVS Azure Well-Architected Documentation for AVS Azure Proactive Resiliency Library for AVS AVS Updates AVS | Marketplace Offer Development Resources Marketplace Training and Support Resources Sell through the commercial marketplace Plan a Consulting Service Offer, applicable for AVS Service Partner Got-To-Market Toolbox AVS | Specialization Resources AVS Specialization details Specialization Overview Specialization Video Specialization Audit Checklist Specialization Assessment AVS | Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training AVS Customer Story IDC white paper: The Business Value of Azure VMware Solution Digital Marketing Campaign (On Demand) AVS Pricing Reference AVS Go Big for Partners AVS Partner Assets Collection AVS Pros (LinkedIn Group) Partners Incentives and Programs AVS Bootcamp Sales Track Azure VMware Solution (AVS) | Microsoft Partner - Mar 4, 2025 - 1:22:59 PM Your overall results Excellent '6/6' AVS | Readiness Resources Excellent '8/10' AVS | Marketplace Offer Development Resources Excellent '3/3' AVS | Specialization Resources Excellent '4/4' AVS | Cosell Acceleration Resources Excellent '9/9' Category Link-Text Link Priority ReportingCategory ReportingSubcategory Weight Context CompleteY/N Note AVS | Readiness Resources Introduction https://learn.microsoft.com/en-us/azure/azure-vmware/introduction High 0 N AVS | Readiness Resources Learning Resources https://aka.ms/AVSLearningResources High 0 N AVS | Readiness Resources Learning Path https://aka.ms/AVSLearningPath High 0 N AVS | Readiness Resources Overview Video https://aka.ms/AVSWhiteboard High 0 N AVS | Readiness Resources AVS Academy https://aka.ms/AVSAcademy High 0 N AVS | Readiness Resources VMware for Azure VMware Solution Master Specialist Exam https://aka.ms/AVSExam High 0 N AVS | Readiness Resources VMware TechZone https://aka.ms/AVSTechZone High 0 N AVS | Readiness Resources Landing Zone Accelerator https://aka.ms/AVSLZA High 0 N AVS | Readiness Resources Landing Zone Accelerator GitHub Repository https://aka.ms/AVSLZAAuto High 0 N AVS | Readiness Resources Landing Zone Assessment Review https://aka.ms/AVSLZAReview High 0 N AVS | Readiness Resources Landing Zone Assessment Network Design Guide https://aka.ms/AVSNDG High 0 N AVS | Readiness Resources Deployment Checklist https://aka.ms/AVSChecklists High 0 N AVS | Readiness Resources Azure Well-Architected Assessment for AVS https://aka.ms/AVSWAF High 0 N AVS | Readiness Resources Azure Well-Architected Documentation for AVS https://aka.ms/AVSWAFdocs High 0 N AVS | Readiness Resources Azure Proactive Resiliency Library for AVS https://aka.ms/AVSAPRL High 0 N AVS | Readiness Resources AVS Updates https://aka.ms/AVSUpdates High 0 N AVS | Readiness Resources Migrating VMware vSphere workloads to Azure VMware Solution https://learn.microsoft.com/en-us/azure/cloud-adoption-framework/scenarios/azure-vmware/migrate High 0 N AVS | Readiness Resources Extending hybrid and multi-cloud agility https://learn.microsoft.com/en-us/azure/azure-vmware/enable-vmware-cds-with-azure High 0 N AVS | Readiness Resources High availability and disaster recovery for VMware workloads https://learn.microsoft.com/en-us/azure/azure-vmware/disaster-recovery-using-vmware-site-recovery-manager High 0 N AVS | Readiness Resources Azure VMware Solution for Desktop virtualization https://learn.microsoft.com/en-us/azure/azure-vmware/azure-vmware-solution-horizon High 0 N AVS | Readiness Resources AVS LAB Automation https://github.com/azure/avslabs High 0 N AVS | Readiness Resources VMware AVS Hands-on Labs https://aka.ms/AVSHOL High 0 N AVS | Readiness Resources AVS Workshop Lab Guide https://aka.ms/AVSHub High 0 N AVS | Marketplace Offer Development Resources Sell through the commercial marketplace https://learn.microsoft.com/en-us/training/paths/sell-through-commercial-marketplace/ High 0 N AVS | Marketplace Offer Development Resources Plan a Consulting Service Offer, applicable for AVS Service https://learn.microsoft.com/en-us/partner-center/marketplace/plan-consulting-service-offer High 0 N AVS | Marketplace Offer Development Resources Partner Got-To-Market Toolbox http://aka.ms/gtmtoolbox High 0 N AVS | Specialization Resources Specialization Overview https://aka.ms/AVSSpecial High 0 N AVS | Specialization Resources Specialization Video https://aka.ms/AVSSpecVideo High 0 N AVS | Specialization Resources Specialization Audit Checklist https://aka.ms/AVSAdvSpecAudit High 0 N AVS | Specialization Resources Specialization Assessment https://aka.ms/AVSAdvSpecAssess High 0 N AVS | Cosell Acceleration Resources AVS Customer Story https://aka.ms/AVSCustomerSuccess High 0 N AVS | Cosell Acceleration Resources IDC white paper: The Business Value of Azure VMware Solution https://aka.ms/AVSIDC High 0 N AVS | Cosell Acceleration Resources Digital Marketing Campaign (On Demand) https://aka.ms/AVSDMK High 0 N AVS | Cosell Acceleration Resources AVS Pricing Reference https://aka.ms/AVSPricing High 0 N AVS | Cosell Acceleration Resources AVS Go Big for Partners https://aka.ms/AVSPartnerGoBig High 0 N AVS | Cosell Acceleration Resources AVS Partner Assets https://aka.ms/AVSPartnerAssets High 0 N AVS | Cosell Acceleration Resources AVS Pros (LinkedIn Group) https://aka.ms/AVSPros High 0 N AVS | Cosell Acceleration Resources Partners Incentives and Programs https://aka.ms/PartnerIncentivesResources High 0 N AVS | Cosell Acceleration Resources AVS Bootcamp Sales Track https://aka.ms/avsbootcamp2023 High 0 N ---------- Category Question Answers Selected Answer Note AVS | Readiness Resources Opportunity and Use Cases Migrating VMware vSphere workloads to Azure VMware Solution Migrating VMware vSphere workloads to Azure VMware Solution AVS | Readiness Resources Opportunity and Use Cases Extending hybrid and multi-cloud agility Extending hybrid and multi-cloud agility AVS | Readiness Resources Opportunity and Use Cases High availability and disaster recovery for VMware workloads High availability and disaster recovery for VMware workloads AVS | Readiness Resources Opportunity and Use Cases Desktop virtualization Desktop virtualization AVS | Readiness Resources Opportunity and Use Cases Azure Migrate and Modernize and Azure Innovate Azure Migrate and Modernize and Azure Innovate AVS | Readiness Resources Training Resources Introduction Introduction AVS | Readiness Resources Training Resources Learning Path Learning Path AVS | Readiness Resources Training Resources Learning Resources Learning Resources AVS | Readiness Resources Training Resources Overview Video Overview Video AVS | Readiness Resources Training Resources AVS Academy AVS Academy AVS | Readiness Resources Training Resources VMware TechZone VMware TechZone AVS | Readiness Resources Training Resources VMware for Azure VMware Solution Master Specialist Exam VMware for Azure VMware Solution Master Specialist Exam AVS | Readiness Resources Training Resources AVS LAB Automation AVS LAB Automation AVS | Readiness Resources Training Resources VMware AVS Hands-on Labs VMware AVS Hands-on Labs AVS | Readiness Resources Training Resources AVS Workshop Lab Guide AVS Workshop Lab Guide AVS | Readiness Resources Deployment Guidance Landing Zone Accelerator Landing Zone Accelerator AVS | Readiness Resources Deployment Guidance Landing Zone Accelerator GitHub Repository Landing Zone Accelerator GitHub Repository AVS | Readiness Resources Deployment Guidance Landing Zone Assessment Review Landing Zone Assessment Review AVS | Readiness Resources Deployment Guidance Landing Zone Assessment Network Design Guide Landing Zone Assessment Network Design Guide AVS | Readiness Resources Deployment Guidance Deployment Checklist Deployment Checklist AVS | Readiness Resources Deployment Guidance Azure Well-Architected Assessment for AVS Azure Well-Architected Assessment for AVS AVS | Readiness Resources Deployment Guidance Azure Well-Architected Documentation for AVS Azure Well-Architected Documentation for AVS AVS | Readiness Resources Deployment Guidance Azure Proactive Resiliency Library for AVS Azure Proactive Resiliency Library for AVS AVS | Readiness Resources Deployment Guidance AVS Updates AVS Updates AVS | Marketplace Offer Development Resources Marketplace Training and Support Resources Sell through the commercial marketplace Sell through the commercial marketplace AVS | Marketplace Offer Development Resources Marketplace Training and Support Resources Plan a Consulting Service Offer, applicable for AVS Service Plan a Consulting Service Offer, applicable for AVS Service AVS | Marketplace Offer Development Resources Marketplace Training and Support Resources Partner Got-To-Market Toolbox Partner Got-To-Market Toolbox AVS | Specialization Resources AVS Specialization details Specialization Overview Specialization Overview AVS | Specialization Resources AVS Specialization details Specialization Video Specialization Video AVS | Specialization Resources AVS Specialization details Specialization Audit Checklist Specialization Audit Checklist AVS | Specialization Resources AVS Specialization details Specialization Assessment Specialization Assessment AVS | Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training AVS Customer Story AVS Customer Story AVS | Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training IDC white paper: The Business Value of Azure VMware Solution IDC white paper: The Business Value of Azure VMware Solution AVS | Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training Digital Marketing Campaign (On Demand) Digital Marketing Campaign (On Demand) AVS | Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training AVS Pricing Reference AVS Pricing Reference AVS | Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training AVS Go Big for Partners AVS Go Big for Partners AVS | Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training AVS Partner Assets Collection AVS Partner Assets Collection AVS | Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training AVS Pros (LinkedIn Group) AVS Pros (LinkedIn Group) AVS | Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training Partners Incentives and Programs Partners Incentives and Programs AVS | Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training AVS Bootcamp Sales Track AVS Bootcamp Sales Track Goal Start a new career Build your plan Take a few minutes to help us build your learning plan with AI—personalized to you! Objectives Timeline Review plan Past 7 days 1.Mar 4 You created a plan plan Develop AI Solutions with Azure AI Services o4 items 2.Mar 4 You edited a plan plan Develop AI Solutions with Azure AI Services o4 items 3.Mar 4 You created a Collection collection Develop AI Solutions with Azure AI Services o8 items 4.Mar 4 You edited a plan plan Run data analytics solutions with Azure Databricks o9 items 5.Mar 4 You started a plan plan Run data analytics solutions with Azure Databricks o9 items 6.Mar 4 You edited a plan plan Help secure your data in the age of AI (1) o4 items 7.Mar 4 You edited a plan plan Implementing data integration and model grounding with Azure AI Foundry and Microsoft Fabric o13 items 8.Mar 4 You started a plan plan Implementing data integration and model grounding with Azure AI Foundry and Microsoft Fabric o13 items 9.Mar 4 You edited a plan plan Build AI apps with Azure Services and best practices o20 items 10.Mar 4 You started a plan plan Build AI apps with Azure Services and best practices o20 items 11.Mar 4 You edited a plan plan Accelerate app development by using GitHub Copilot o23 items 12.Mar 4 You started a plan plan Accelerate app development by using GitHub Copilot o33 items 13.Mar 4 You edited a plan plan Help secure your data in the age of AI o4 items 14.Mar 4 You started a plan plan Help secure your data in the age of AI o4 items 15.Feb 28 You created a Collection collection 46307064's Collection 9 o0 item Your activity feed shows up to 30 interactions over the past 30 days. Previo g data issue rural system information management system education 46307064 0

Reputation points Mar 4, 2025, 2:34 PM isc tshingombe exam ims., Access Control and Identity Management.pdf Microsoft Authenticator experimental career by tshingombe editEdit gearManage timeHistory Publication date 2025-02-03 Usage Attribution-NonCommercial-ShareAlike 4.0 International Topics engineering Collection opensource Language English Item Size 7.7M this item is currently being modified/updated by the task: book_pre-cataloger experimental Addeddate 2025-03-04 10:53:21 Engsecur 20000 Identifier career-experimental-security-isc-microsoft-tshingombe Identifier-ark ark:/13960/t4rc1nb9p Scanner Internet Archive HTML5 Uploader 1.7.0 plus-circle Add Review Reviews There are no reviews yet. Be the first one to write a review. 0 Views DOWNLOAD OPTIONS download 5 files COMMA-SEPARATED VALUES download 12 files PDF download 1 file TORRENT download download 1 file WEB VIDEO TEXT TRACKS download download 2 files WORD DOCUMENT download 24 Files download 24 Original SHOW ALL IN COLLECTIONS Community Texts Uploaded by Rdferz on March 4, 2025 Why get certified 13 reasons for seeking training and certification With testimonials from IT networkers who met the challenge Get started © 2022 Cisco and/or its affiliates. All rights reserved. Get certified eBook2 eBook Cisco Public Why get certified Summary Certification benefits We live in exciting times to be working in technology. While the words “digital transformation” can sometimes seem repetitive, we are indeed in a digital era, where so much of our technology is dramatically changing. Cloud has evolved from being a virtual non-entity to exerting a significant influence on networking, data center, security, analytics, and virtualization. At the same time, cybersecurity has become critical across all technology sectors and is constantly evolving to counter increasingly sophisticated cyberattacks. Other transforming technologies include the data center, which now plays a central role in the business landscape. The Internet of Things is now virtually important to our digital lives in its ability to connect a staggering amount of data and devices. And software-defined networking (SDN) has ushered in a sea change in how we can manage networks via automation. But through it all, routing and switching remain the core foundation of knowledge from which IT networking professionals can build their career as they learn to Connect, Secure, and Automate. These vibrant technological developments culminating all at once can seem overwhelming—you need to be able to catch the wave of change and ride it smoothly. This is precisely why we believe right now is the best time to explore how solid training and certification can keep you focused and help make you a technical superstar in your organization. © 2022 Cisco and/or its affiliates. All rights reserved. 23 eBook Cisco Public Pearson VUE surveyed more than 29,000 candidates who prepared for and earned IT certifications during the previous 12 months. Its resulting 2021 Value of IT Certification Report 1 features insights from North America, Latin America, Middle East and Africa (MEA), India, Greater China, Japan and the rest of Asia Pacific (APAC). Demand for IT talent is growing, with a 16-percent increase in the number of certifications earned between 2019 and 2020. Certified employees were less likely than their uncertified peers to be using their current skills and were more likely to be using the latest technologies. Certified employees were also more likely to be confident in their ability to meet their employer’s goal, with a desire to certify holds strong and is on the rise. Of candidates who earned certifications in 2020, 86 percent plan to pursue additional certifications over the next 12 months. 2 Cisco can offer you training and certification for all of the hot fields. But, first, you need more answers to the question of why it matters. With this eBook, we’d like to share with you our answers—gathered from interactions over the years with Cisco certification holders—to the basic question of “why get certified?” We interviewed your peers in the certification community about the personal value of Cisco certification to them, and arrived at a dozen great reasons to give training and certification some serious thought. Have a read through the following pages and be sure to follow the links for the fuller story on the various certification holders we have spotlighted here. We trust that you’ll walk away with a sense of what training and certification can do for you in your career. Why get certified Summary Certification benefits © 2022 Cisco and/or its affiliates. All rights reserved. 3© 2022 Cisco and/or its affiliates. All rights reserved. Cisco Public Meet Ajet Ajet is a network engineer at a Cisco partner in Australia. Ajet’s employer trusts him with customer networks, and he’s earned a solid reputation as CyberOps Associate, CyberOps Packet Tracer, online training, presentations, videos, mentors, simulations, labs, Cisco Press books—Ajet has left no stone unturned in his quest to understand the security field. Why get certified Summary Certification benefits 73 percent cited the need to obtain particular skills, knowledge, or competencies as their reason for earning an IT certification.3 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Knowledge: The systematic study of your field via a certification program can help you understand it inside and out so that you are more adept at attacking technical and business problems at many levels to arrive at a solution. > Get the full story on Ajet. “Cisco is the biggest network vendor in the world, so if you want to learn networks, you turn to Cisco—with Cisco certification, you learn all different facets of security. It gives you an edge to design the right solution, right away—a solution that’s more secure, available, and scalable.” —Muhammad Ismail, Senior Network Engineer, Etisalat Misr Cisco Public Meet Ismail Ismail is a senior network engineer at Etisalat Misr in Egypt. Ismail’s employer trusts him with the most critical customer networks, and he’s a reliable resource for his employer and for his customers

Principles of Industrial Engineering 10-15 hrs 6,867 learners You Will Learn How To oDefine the principle of industrial engineering oDiscuss the functions and tools of industrial engineerin... oExplain the organizational structure of indus... Read More ... [Message clipped] View entire message tshingombe fiston Jul 28, 2024, 1:13 PM to TSHINGOMBEKB 1.Home 2.Engineering & Construction 3.STEM 4.Electrical Engineering - Electrical Transform... Electrical Engineering - Electrical Transformer Components Learn about electrical transformer construction and components with this free online Electrical Engineering course! This free online Electrical Engineering course will teach you about electrical transformers, why we use them, and the features and functionality of their main components. Electrical transformers are an essential component in any electrical distribution system and are vital for proper energy transmission through an electrical grid. This free course uses detailed 3D models to teach you about an electrical transformers functions and components. COURSE PUBLISHER saVRee Start Course Now Alison's New App is now available on iOS and Android! Download Now Explore Courses Claim Your Certificates Discover Careers More LMS Continue Learning Tshingombe Fiston Finish Your Profile 100% Remaining Alison ID: 37876299 Continue Learning For You Dashboard Career Ready plan Create Resumé/CV Learner Report Upgrade to Premium Claim Your Certificates Account Settings FAQs Logout FREE ONLINE COURSE CATEGORIES IT Health Language Business Management Personal Development Sales & Marketing Engineering & Construction Teaching & Academics English LEARN ABOUT ALISON Learning on Alison About Alison Courses Our Story Board of Directors Alison Programmes Our Course Creators Empower Alison Index Open Positions Media Centre Blog QUALITY FREE LEARNING All Certificates All Diplomas Hubs Accreditation Graduate Outcomes Alison Testimonials COVID19 Emergency Courses Premium Learning Shop Graduate Profiles DISCOVER MORE Download App Access Free LMS Career Ready Plan Discover Careers Alison Profile Build Your Resumé Aptitude Test Verbal Reasoning Test Numerical Reasoning Test Abstract Reasoning Test Free Personality Test Free Well-being Check up Integrate Alison's API EARN ON ALISON Create Courses on Alison Affiliate Programme Refer a Friend EVENTS E-learning Africa Upcoming Webinars FAQs Customer Support © Alison 2024 Privacy Terms Cookie Policy Sitemap In This Free Course, You Will Learn How To Identify all of an electrical transf... Explain how a Buchholz relay works... Describe how oil level measurement w... Describe how transformer temperature... View All Learning Outcomes Course Modules Course Description Alison Certificates Electrical transformers are a common site in any electrical distribution system. In order to understand how power is transmitted through an electrical grid, you will need to learn more about transformers. This free online course introduces you to all of an electrical transformer's main components (core, windings etc.). The course shows you how a Buchholz relay works. You will learn about oil level measurements and how transformer temperature measurement works. The course then describes how silica gel breathers and tap changers work (on and off load). This course will give you all the information you need to know about electrical transformers and can also be used later as a refresher course. Its an ideal course for anyone working/training in an electrical engineering or power engineering industry. Interactive 3D models are used extensively to show you exactly how each of the transformer parts work. The course is packed with 2D images, 2D animations and 3D animations. Written content has been read aloud so that you can 'learn on the go' without needing to watch the screen constantly. So, why wait? Start the course today and gain valuable knowledge on how electrical transformer components work! Start Course Now y You learned 2 days this month 2 days more than last month 9 mins Total Time Learning 26th Jul | 6 mins Best Learning Day Average number of hours you learn on days of the week Fridays are your best day Sunday you study the least Want to make your learnin On Sat, Jul 27, 2024 at 6:48 PM TSHINGOMBEKB TSHITADI wrote: https://alison.com/shop?utm_campaign=5844_sale1_march2023_on_nongrad&utm_source=outbound%20marketing&utm_medium=email&utm_datesent=2023-03-02&utm_emailtype=marketing&utm_segment=1155&utm_campaigntheme=b2c&utm_subjecttone=exciting tshingombe fiston Jul 28, 2024, 1:30 PM to TSHINGOMBEKB All Courses Education Online Teaching Courses and Certification Our free online teaching and education courses will give you the means to inspire the next generation. Education is the key to unlocking potential for a better future. With our classes, you can learn about educational psychology, which is key for improving teaching methods and fulfilling instructional roles. We also offer courses that focus on how to work with students with special needs as well as the different learning processes an......Read More 1217 Free Courses 27,169,912 Learners 6,244,700 Certificates & Diplomas Earned Explore Top Subjects Most Popular Teaching & Academics Courses Certificate education Infection Control in Health Care 3-4 hrs 11,260 learners You Will Learn How To Define infectious diseases and various types of infectio... List the common pathways of transmission in healthcare s... Identify the core principles underlying effective infect... Describe the correct technique for handwashin... Read More More Info Start Learning Certificate education Safeguarding Children and Vulnerable Adults 2 - 3 hrs 17,093 learners You Will Learn How To Discuss the need for safeguarding children and vulnerabl... Recognize various signs of abuse in children and vulnera... Distinguish between different types of child ... Read More More Info Start Learning Certificate education Caregiver Support Services Training - Preventing the Spread of Infection 2 - 3 hrs 32,664 learners You Will Learn How To Explain the basic tips for safe care Discuss an overview of pathogens, bacteria, and viruses a... Read More More Info Start Learning Certificate education Fundamentals of Domestic Violence and Abuse 4-5 hrs 50,518 learners You Will Learn How To Explain the concept of domestic violence and abuse Discuss the risk involved in domestic violence Outline different types of domestic violence Read More More Info Start Learning Certificate education Understanding Child Development and Disabilities 2 - 3 hrs 27,639 learners You Will Learn How To Define what is meant by child development List the factors that impact child development Explain how adults can provide valuable care ... Read More More Info Start Learning Certificate education Lifeguard Training Fundamentals 2 - 3 hrs 12,838 learners You Will Learn How To Define the characteristics of a professional lifeguard List the duties of a professional lifeguard Distinguish between a person in distress and a person dr... Describe the effective observation skills tha... Read More More Info Start Learning Certificate education Comprehensive Guide to Defensive Driving 2 - 3 hrs 4,804 learners You Will Learn How To Define the concept of defensive driving and its signific... Discuss the concept of hazard perception and risk assess... Indicate the factors that can affect a driver... Read More More Info Start Learning Certificate education Hand Hygiene Steps, Practices and Strategies 3-4 hrs 444 learners You Will Learn How To Describe the importance of hand hygiene in both... Explain the various types of hand hygiene practices and ... Classify the consequences of poor hand hygien... Read More More Info Start Learning Certificate education Fundamentals of RBT Certification Exam - Behavior & Crisis Management 3-4 hrs 7,847 learners You Will Learn How To List the important skills and terms to be known about th... Explain the role of an RBT in ensuring well-being of chi... Indicate various strategies to prepare for th... Read More More Info Start Learning Certificate education Autism Spectrum Disorder in Early Childhood 3-4 hrs 18,808 learners You Will Learn How To Explain the epidemiology of autism Outline the development skills and characteristics of ch... Summarize body and object use skills of child... Read More More Info Start Learning Certificate education Defensive Driving - Essential Principles & Practices 3-4 hrs 42,353 learners You Will Learn How To Identify various causes of road traffic accidents Classify different types of drivers Indicate the necessary characteristics that m... Read More More Info Start Learning Certificate education Working with Students with Special Educational Needs 2 - 3 hrs 173,068 learners You Will Learn How To Describe the fundamentals of special education Outline the most common disabilities encountered in the ... Outline a basic individual education plan (IE... Read More More Info Start Learning Certificate education Good Clinical Practice - ICH Guidelines E6 R2 3-4 hrs 11,798 learners You Will Learn How To Identify the role of ICH and the duties of its working g... Discuss GCP requirements regarding conducting a clinical... Evaluate the team configuration of IECs and I... Read More More Info Start Learning Certificate education Childcare and EYFS 2 - 3 hrs 87,403 learners You Will Learn How To Solve potential hazards at home and learn to prevent out... Classify the various signs of abuse and neglect Define Early Years Foundation Stage (EYFS) and explain t... Identify the main points that help close the ... Read More More Info Start Learning Most Popular Teaching & Academics Courses Certificate education Hydrogen Sulphide Safety Training 2 - 3 hrs 614 learners You Will Learn How To Identify the physical and chemical properties of hydroge... Recognise sources of H2S exposure in different workplace... Evaluate the risks associated with the exposu... Read More More Info Start Learning Certificate education Safe Practices for Working at Height 2 - 3 hrs 461 learners You Will Learn How To Define the United Kingdom WAHR 2005 regulations List the potential hazards and risks of working at heigh... Recognise the steps to develop a risk assessm... Read More More Info Start Learning Certificate education OSHA Essentials - Forklifter Operations & Safety 3-4 hrs 5,428 learners You Will Learn How To Classify different types of forklifts according to the f... Explain a forklift's stability triangle, and load centre... Discuss factors determining the forklift's st... Read More More Info Start Learning Certificate education Anger Management: A Guide to Emotional Regulation and Conflict Resolution 3-4 hrs 3,128 learners You Will Learn How To Identify the effects of anger on both the body and mind Outline personal triggers and stressors that lead to ang... Define anger journaling and its use in identi... Read More More Info Start Learning Certificate business Environmental Management and Legal Compliance 2 - 3 hrs 3,498 learners You Will Learn How To Define 'global warming' and 'climate change' Describe the role of industries and businesses in drivin... Discuss those industries that are contributin... Read More More Info Start Learning Certificate education Childcare and Young People Development 2 - 3 hrs 20,074 learners You Will Learn How To Define and describe in detail childcare with all its ele... Explain the key personal and professional features nee... Discuss the development process in children a... Read More More Info Start Learning Certificate education Child Protection and Welfare 3-4 hrs 5,226 learners You Will Learn How To Describe the importance and the need for child protectio... Identify different types of child abuse, including physi... Recognise signs and symptoms of child abuse and neglect Evaluate the role of education, health profes... Read More More Info Start Learning Certificate education Montessori Teaching - Fundamental Concepts & Principles 2 - 3 hrs 53,222 learners You Will Learn How To Describe the historical context of early childhood educa... Discuss Dr Maria Montessori's contributions to ECE and t... Indicate the theories of childhood developmen... Read More More Info Start Learning Certificate education Phlebotomy, Venipuncture and Specimen Handling 2 - 3 hrs 4,936 learners You Will Learn How To Define the scope and fundamental practices of phlebotomy... Identify various blood collection tubes, additives, and ... Assess patient conditions and choose appropri... Read More More Info Start Learning Certificate education Phlebotomist Training Course 2 - 3 hrs 93,563 learners You Will Learn How To Summarize the knowledge, skills and guidelines needed fo... Identify the primary responsibilities of a phlebotomist ... Recall medical terminology that involves drawing blood f... Discuss infection control, safety standards a... Read More More Info Start Learning Certificate education Dog Training Careers - Become a Professional Dog Trainer 2 - 3 hrs 14,363 learners You Will Learn How To Identify what to include in a confirmation agreement let... Recall what to include during a dog training consultatio... Explain what to do if you forget to tell your... Read More More Info Start Learning Certificate education Working as a Teaching Assistant 3-4 hrs 14,573 learners You Will Learn How To Define and list the characteristics of a teaching assist... Distinguish between the roles of learning support assist... Explain how goal-oriented schools operate Outline the school development plan and manag... Read More More Info Start Learning Certificate education Understanding Epilepsy 3-4 hrs 5,256 learners You Will Learn How To Define 'epilepsy' Classify epileptic seizures Discuss the symptoms and causes of epilepsy Explain how to diagnose epilepsy with an EEG Read More More Info Start Learning Certificate education First Aid: A Comprehensive Guide to Saving Lives 2 - 3 hrs 2,995 learners You Will Learn How To Discuss how to respond to various accidents, injuries an... Explain why ensuring the safety of the victim and the ca... Distinguish between physical health and menta... Read More More Info Start Learning Certificate education Basics of Manual Handling in the Workplace 2 - 3 hrs 57,858 learners You Will Learn How To Explain the concept of manual handling Summarise the different types of manual handling in the ... Outline the factors that lead to injuries in ... Read More More Info Start Learning Certificate education Early Childhood Crisis and Trauma 3-4 hrs 16,908 learners You Will Learn How To Define terms like 'disasters', 'crises' and 'trauma' Recognize the effects of trauma on human psychology Explain the interaction between children and ... Read More More Info Start Learning Previous 1 2 3 4 5 6 7 8 9 10 ... 77 Next Showing 17-32 of 1217 Courses Benefits Of An Alison Certificate Certify Your Skills A CPD accredited Alison Certificate certifies the skills you've learned Stand Out From The Crowd Add your Alison Certification to your resumé and stay ahead of the competition Advance in Your Career Share your Alison Certification with potential employers to show off your skills and capabilities Top STEM Courses View all STEM Courses Top Teaching Courses Most Popular Teaching & Academics Courses Certificate education Mastering Modern Day Parenting Techniques 3-4 hrs 1,422 learners You Will Learn How To Discuss the different parenting styles and their effects... Describe the key components of emotional intelligence an... Summarize the key strategies for effective co... Read More More Info Start Learning Certificate education Physical Education - Coaching Styles and Techniques 2 - 3 hrs 34,404 learners You Will Learn How To Describe the effectiveness of a coach in improving team ... Illustrate effective coaching styles and techniques Explain legal ergogenic aids such as nutritio... Read More More Info Start Learning Certificate education Learning Support Assistant (LSA) Training 2 - 3 hrs 5,371 learners You Will Learn How To Explain the role of a Learning Support Assistant (LSA) Indicate the various learning support activities List monitoring processes and procedures Read More More Info Start Learning Certificate education First Aid for Pediatric Emergencies 2 - 3 hrs 5,867 learners You Will Learn How To Classify various pediatric age groups Compare adult medicine with pediatric medicine Recognise the method of performing CPR on chi... Read More More Info Start Learning Certificate education AS9100D Quality Management System (QMS) for Aerospace Industry 3-4 hrs 1,986 learners You Will Learn How To Compare different AS standards on the basis of their imp... List the major features of the AS9100D standard Recognize the importance of the organizations... Read More More Info Start Learning Certificate education Introduction to Forest Schooling 2 - 3 hrs 1,352 learners You Will Learn How To Define the 'forest school' teaching model Explain the nature-based values and the role of forest s... Summarise the procedures involved in a forest school pro... Identify risks and know control measures rele... Read More More Info Start Learning Certificate education Signs of Substance Abuse and What to Do 3-4 hrs 8,514 learners You Will Learn How To Outline commonly misused substances and disorders relate... Describe different types of substances as well as their ... Discuss the importance and principles of prev... Read More More Info Start Learning Certificate education Special Education Needs and Disabilities (SEND) Inclusion in Schools 2 - 3 hrs 1,376 learners You Will Learn How To Explain the concepts of SEND along with the laws and mod... List the principles of the SEND code of practice and exp... Distinguish between inclusive and non-inclusi... Read More More Info Start Learning Certificate education Positive Handling and Behavioural Training in Schools 2 - 3 hrs 3,969 learners You Will Learn How To Explain the importance of positive handling in schools Outline the components of the 'SCARF' Model and their si... Compare acceptable and unacceptable student b... Read More More Info Start Learning Certificate education Fundamentals of Serving Safe for Food Handlers 2 - 3 hrs 2,042 learners You Will Learn How To Outline the importance of food safety and safe food hand... Indicate the seven different steps involved in food prep... Distinguish the food items into perishable an... Read More More Info Start Learning Certificate ... [Message clipped] View entire message Show trimmed content • Scanned by Gmail tshingombe fiston Jul 28, 2024, 1:46 PM to TSHINGOMBEKB, me tshingombe fiston Jul 26, 2024, 1:59 PM (2 days ago) to ALISON, TSHINGOMBEKB, me Conversation opened. 1 read message. Skip to content Using Gmail with screen readers 50 of 4,150 [ZendTo] 5Y Data Request Inbox ZendTo Fri, Mar 8, 10:31 AM (3 days ago) to me This is an automated message sent to you by the ZendTo service. Eskom Automation has dropped off a file for you. IF YOU TRUST THE SENDER and are expecting to receive a file from them, you may choose to retrieve the drop-off by clicking the following link (or copying and pasting it into your web browser): https://zendto.eskom.co.za/pickup?claimID=rdkqXdn2Udun4uz3&claimPasscode=2WbpNXmkjh5izpQg&emailAddr=49846 You have 21 days to retrieve the drop-off; after that the link above will expire. If you wish to contact the sender, just reply to this email. The sender has left you a note: Requested files Full information about the drop-off: Claim ID: rdkqXdn2Udun4uz3 Claim Passcode: 2WbpNXmkjh5izpQg Date of Drop-off: 2024-03-08 10:31:05 — Sender — Name: Eskom Automation Organization: Eskom Email Address: noreply.portal@eskom.co.za — File — Name: ESK8572.csv Description: Eskom 5Y Data Request Size: 12.7 MB Copyright © 2024 ZendTo | About ZendTo This service is powered by a copy of ZendTo Disclaimer NB: This Email and its contents are subject to the Eskom Holdings SOC Ltd EMAIL LEGAL NOTICE which can be viewed at https://www.eskom.co.za/about-eskom/email-legal-spam-disclaimer/ Conversation opened. 1 unread message. Skip to content Using Gmail with screen readers 1 of 4,152 [ZendTo] You are trying to drop off some files Inbox ZendTo 9:54 AM (4 minutes ago) to me This is an automated message sent to you by the ZendTo service. Name: tshingombe Organization: engineering tshingombe/st peace college Email: tshingombefiston@gmail.com You have asked us to send you this message so that you can drop-off some files for someone. IGNORE THIS MESSAGE IF YOU WERE NOT IMMEDIATELY EXPECTING IT! Otherwise, continue the process by clicking the following link (or copying and pasting it into your web browser): https://zendto.eskom.co.za/dropoff?auth=9a23345e836a4f1b1afc6dec30d1f050 Copyright © 2024 ZendTo | About ZendTo This service is powered by a copy of ZendTo Disclaimer NB: This Email and its contents are subject to the Eskom Holdings SOC Ltd EMAIL LEGAL NOTICE which can be viewed at https://www.eskom.co.za/about-eskom/email-legal-spam-disclaimer/ Home Personal Info CPD VA Finance CPD Activities Request Invitation New Application Registration Status fiston tshingombe Home CPD Pre-Validated Activities CPD Pre-Validated Activities Validation Number. sort descending Provider. sort descending Course Category. sort descending Name . sort ascending Category. sort descending Notional Hours. sort descending Credits Earned. sort descending Nature of Activity. sort descending Discipline. sort descending Sub Discipline. sort descending Valid From. sort descending Valid To. sort descending All Categories SEMC-BLD-02 IESSA Refresher courses 2-Day Course on Design of High-Rise Buildings: Johannesburg, Cape Town and Durban 20.00 2.00 1/1/2015 12/31/2019 SEMC-ERC-02 IESSA Refresher courses 2-Day Course on Eurocode Design of Concrete Structures: Johannesburg, Cape Town and Durban 20.00 2.00 1/1/2015 12/31/2019 IESSACIEmeetings004/11 Illumination Engineering Society of South Africa Refresher courses CIE Meetings April 20.00 0.20 6/1/2011 5/31/2013 IESSACIEmeetings002/11 Illumination Engineering Society of South Africa Refresher courses CIE Meetings February 2.00 0.20 6/1/2011 5/31/2013 IESSACIEmeetings001/11 Illumination Engineering Society of South Africa Refresher courses CIE Meetings January 2.00 0.20 6/1/2011 5/31/2013 IESSACIEmeetings003/11 Illumination Engineering Society of South Africa Refresher courses CIE Meetings March 2.00 0.20 6/1/2011 5/31/2013 CEM-10.5/2014 IESSA Refresher courses Combination of Environmental Management Awareness for Local Government CEM 09.1.3 and Introduction to Integrated Waste Management CEM 09.6.2 20.00 2.00 1/1/2014 12/31/2014 CEM-10.6/2014 IESSA Refresher courses Combination of Introduction to Remediation CEM 06.5.2 and CEM 10.1 40.00 4.00 1/1/2014 12/31/2014 Waterview Corner Building, 2 Ernest Oppenheimer Avenue, Bruma Lake Office Park, Bruma, 2198, Johannesburg engineer@ecsa.co.za +27116079500 Copyright © 2024. All rights reserved. ... [Message clipped] View entire message tshingombe fiston Aug 2, 2024, 9:15 PM to TSHINGOMBEKB, me On Sat, 27 Jul 2024, 18:48 TSHINGOMBEKB TSHITADI, wrote: https://alison.com/shop?utm_campaign=5844_sale1_march2023_on_nongrad&utm_source=outbound%20marketing&utm_medium=email&utm_datesent=2023-03-02&utm_emailtype=marketing&utm_segment=1155&utm_campaigntheme=b2c&utm_subjecttone=exciting tshingombe fiston Aug 4, 2024, 1:44 PM 0 notifications total Dialog content start. Previewing Image attachment Dialog content end. - new feed updates notifications - Sales Nav Search appearances How tshingombe fiston Aug 4, 2024, 1:54 PM to TSHINGOMBEKB, me resources and courses on diplome electrical engineering - handpicked by experts Did you mean: diploma electrical engineering? 426 courses Certificate Beginner Level engineering Electrical Engineering - Electrical Transformer Components 0% complete You Will Learn How To oIdentify all of an electrical transformer's main compone... oExplain how a Buchholz relay works oDescribe how oil level measurement works Read More More Info Continue Certificate Advanced Level engineering Electrical Engineering in Theory 3-4 hrs 3,261 learners You Will Learn How To oRecall the fundamentals of electricity and its significa... oExplain DC networks, network theorems, and network diagr... oAnalyze single-phase AC circuits for RMS value, form fac... oExplain the basic principles of the operation... Read More More Info Start Learning Certificate Beginner Level engineering Trigonometry in Electrical Engineering 5-6 hrs 3,958 learners You Will Learn How To oDefine trigonometry oRecall the Pythagorean theorem oIdentify the various types of triangles Read More More Info Certificate Beginner Level engineering Electrical Measuring Instrumentation 0% complete You Will Learn How To oCategorize electrical measuring instruments oExplain how to repair such instruments oRecognize the measurement of electric resista... Read More More Info Continue Diploma Beginner Level engineering Diploma in Electrical Studies 11% complete You Will Learn How To oDiscuss the significance of electrical trade in today's ... oDescribe the basic electrical wiring system in residenti... oState the hazards involved in working with electric powe... oList the various types of electrical device b... Read More More Info Continue Certificate Intermediate Level engineering Maintenance and Repair of Marine Electrical Equipment 4-5 hrs 3,542 learners You Will Learn How To oExplain the methodology of electrical maintenance oDiscuss the maintenance of switchboards oAnalyze the detection of an electric malfunct... Read More More Info Start Learning Certificate Intermediate Level engineering Introduction to Marine Electrical 4-5 hrs 5,061 learners You Will Learn How To oExplain the standard symbols and units used in electroni... oDiscuss the basic science behind electricity oDescribe electromotive force (EMF) and electr... Read More More Info Start Learning Certificate Beginner Level engineering Introduction to Basic Electrical Drawings and Test Equipment 2 - 3 hrs 55,776 learners You Will Learn How To oList the plans and drawings that are included in electri... oDescribe the various terms associated with electrical dr... oIndicate the drawing layout, the common drafti... Read More More Info Start Learning o40 Million + Learners o8 Million + Graduates o193 Countries Certificate Advanced Level engineering Introduction to Electrical Technology 5-6 hrs 5,515 learners You Will Learn How To oDescribe how to safely lift and shift equipment oDiscuss the mechanism and prevention of electric shocks oAnalyze different artificial respiration meth... Read More More Info Start Learning Certificate Beginner Level engineering Fundamentals of Marine Engineering 2 - 3 hrs 926 learners You Will Learn How To oDistinguish between nautical science and marine engineer... oIdentify profitable job opportunities in both public and... oExplain the underlying math and physics in ma... Read More More Info Start Learning Certificate Advanced Level engineering NFPA 70E (2024) - Navigating Workplace Electrical Safety & Essential Updates 3-4 hrs 5,294 learners You Will Learn How To oDefine the NFPA 70 series and the standards present in t... oRecognize the types of premises and installations that a... oIndicate the major responsibilities of employ... Read More More Info Start Learning Diploma Advanced Level engineering Diploma in Solar Energy Engineering 10-15 hrs 27,147 learners You Will Learn How To oDiscuss the different available means of harnessing sola... oDescribe the devices commonly used for solar energy coll... oExplain how solar radiation reaches the surfa... Read More More Info Start Learning Certificate Beginner Level engineering Fundamentals Electrical Fundamentals 5-6 hrs 10,335 learners You Will Learn How To oDefine the key terms and formulae of electrical theory oAnalyze the key circuit parameters of resistance, capaci... oExplain the basic laws and effects of electric current oDescribe the workings of DC circuits in both ... Read More More Info Start Learning Certificate Intermediate Level education Introduction to Electrical Maintenance 4-5 hrs 14,753 learners You Will Learn How To oReview the process to check or measure air gap dimension... oList the classification of electrical insulation based o... oExplain the difference between aligning coupl... Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Marine Electrical 20-30 hrs 7,432 learners You Will Learn How To oExplain the standard symbols and units used in electroni... oDescribe electro-motive force (EMF) and electric current oOutline the factors affecting capacitance value oDefine the concepts of resistance, conductor,... Read More More Info Start Learning Certificate Intermediate Level engineering Fundamentals of Electrical Three-Phase Power Transformers 4-5 hrs 2,855 learners You Will Learn How To oExplain the working principle of a power transformer oDistinguish between ideal and real transformers oExplain how the losses in a real transformer ... Read More More Info Start Learning Overwhelmed by career choices? Let us guide you. Discover the career most suitable for you and get started in the field with a step-by-step plan. Get Your Plan Certificate Advanced Level engineering Essentials of Electrical Safety 2 - 3 hrs 10,925 learners You Will Learn How To oIdentify the effects of electric current on the human bo... oList the general safety rules for working with electrici... oDescribe the available features of direct and alternatin... oExplain the relationship between voltage, cur... Read More More Info Start Learning Diploma Advanced Level engineering Diploma in Basics of Electrical Technology and Circuit Analysis 15-20 hrs 9,884 learners You Will Learn How To oIdentify different types of resistors and their applicat... oDiscuss the mechanism and prevention of electric shocks oEvaluate the process of finding the unknown r... Read More More Info Start Learning Certificate Beginner Level engineering Introduction to the Electrical Trade 2 - 3 hrs 59,545 learners You Will Learn How To oOutline the basics of electrical wiring systems oIdentify the job requirements of the electrical trade oDescribe the effects of an electric shock Read More More Info Start Learning Certificate Beginner Level management Engineering Project Management 2 - 3 hrs 16,247 learners You Will Learn How To oDefine the concept of engineering and its role among oth... oDescribe the discipline of engineering management and h... oDiscuss what is meant by project management and its his... oDistinguish between engineering project manag... Read More More Info Start Learning Certificate Beginner Level engineering Introduction to Electrical Wiring Systems 2 - 3 hrs 48,132 learners You Will Learn How To oState the uses of electrical device boxes oDiscuss the terms associated with device boxes oApply the steps involved in making a 90-degre... Read More More Info Start Learning Diploma Advanced Level engineering Diploma in Electrical Technology 10-15 hrs 7,884 learners You Will Learn How To oExplain the basic concepts of magnetism and distinguish... oDefine electromagnetism and analyze the various ways to ... oDiscuss the fundamentals of electricity and define the b... oIdentify circuit parameters and explain the b... Read More More Info Start Learning Certificate Advanced Level engineering Fundamental of Basic Electrical Circuits 4-5 hrs 5,683 learners You Will Learn How To oIdentify the basic circuit elements and their applicatio... oDiscuss the operations of sinusoid and phasors in an ele... oDiscuss the various properties of resistors, ... Read More More Info Start Learning Certificate Advanced Level engineering Diagnose Basic Car Electrical Problems Using Wiring Diagrams 2 - 3 hrs 1,705 learners You Will Learn How To oDefine 'voltage', 'current' and 'resistance' oState what every basic electrical circuit needs to opera... oDescribe the four types of faults that can af... Read More More Info Start Learning Did you mean: diploma electrical engineering? 426 courses Certificate Advanced Level engineering Electrical Technology - Basic Laws and Single Phase AC Circuits 4-5 hrs 1,470 learners You Will Learn How To oDefine Ohm's law oAnalyze Kirchoff's voltage law and Kirchoff's current la... oEvaluate the process of finding the unknown r... Read More More Info Start Learning Certificate Advanced Level engineering An Introduction to Solar Energy Engineering 4-5 hrs 7,389 learners You Will Learn How To oRecall the different ways of harnessing solar energy oDescribe the devices commonly used for solar energy coll... oExplain how solar radiation reaches the surfa... Read More More Info Start Learning Certificate Beginner Level management Basics of Engineering Management 2 - 3 hrs 8,758 learners You Will Learn How To oDefine 'engineering management' and describe the skills ... oDefine 'decision analysis' and explain how it can be use... oIdentify the various components of the strategic plannin... oDiscuss the different elements of cost accou... Read More More Info Start Learning Certificate Beginner Level engineering Guide to Transformer Maintenance 2 - 3 hrs 1,323 learners You Will Learn How To oIdentify all parts of a power transformer oDescribe the function of each transformer part oExplain how a transformer's parts are connected to carry... oRecognize when transformer parts are faulty Read More More Info Start Learning Diploma Advanced Level engineering Diploma in Basic Electrical Circuits 10-15 hrs 7,060 learners You Will Learn How To oIdentify the basic circuit elements and their applicatio... oDiscuss the various properties of resistors, capacitors,... oDiscuss the mesh and nodal analysis of variou... Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Structural Engineering and Construction Site Safety 6-10 hrs 27,434 learners You Will Learn How To oExplain slab centring, beam reinforcements, and beam arr... oDescribe the processes used in slab reinforcements oDiscuss the systems for staircase placement, ... Read More More Info Start Learning Certificate Advanced Level engineering Introduction to Industrial Engineering 4-5 hrs 7,073 learners You Will Learn How To oDefine the concept of industrial engineering oExplain the different types of industries in the field oIdentify the functions of industrial engineer... Read More More Info Start Learning Certificate Intermediate Level engineering Marine Electrical - Distribution System and Maintenance 4-5 hrs 2,862 learners You Will Learn How To oAnalyze the layout of an AC shipboard installation oDiscuss the layout of a DC shipboard installation oDescribe the power distribution system onboar... Read More More Info Start Learning o40 Million + Learners o8 Million + Graduates o193 Countries Certificate Beginner Level health Health and Safety - Electrical Safety in the Workplace 2 - 3 hrs 4,774 learners You Will Learn How To oSummarize the definition of electricity oOutline the standards for electrical use oDiscuss the potential electrical hazards that... Read More More Info Start Learning Certificate Advanced Level education Chemical Engineering Overview 2 - 3 hrs 3,711 learners You Will Learn How To oDistinguish between a chemist and a chemical engineer oSummarize the responsibilities of a chemical engineer oExplain the fluid flow relationships between energy and ... oIdentify the common microorganisms used in wa... Read More More Info Start Learning Certificate Intermediate Level engineering Mechanical Engineering Principles and Design Concepts 3-4 hrs 6,953 learners You Will Learn How To oExplain the concept, achievements, and benefits of mecha... oState the ideal expectations from the mechanical enginee... oDiscuss the conditions needed for a state of ... Read More More Info Start Learning Certificate Intermediate Level engineering Maintenance and Troubleshooting for Electronic and Electrical Devices 4-5 hrs 14,746 learners You Will Learn How To oDescribe the work of a troubleshooter oList the various tools used by a troubleshooter oSummarise standard electronic and electrical ... Read More More Info Start Learning Certificate Advanced Level engineering Fundamentals of Value Engineering Tools and Techniques 4-5 hrs 2,844 learners You Will Learn How To oDiscuss the cost-function relationship of a product in v... oExplain how value engineering can be applied to the cost... oDiscuss the advantages of applying the FAST m... Read More More Info Start Learning Diploma Intermediate Level business Diploma in Principles of Industrial Engineering 10-15 hrs 7,380 learners You Will Learn How To oDefine the principle of industrial engineering oDiscuss the functions and tools of industrial engineerin... oExplain the organizational structure of indus... Read More More Info Start Learning Certificate Beginner Level education Study of Electrical Measuring Instrumentation 4-5 hrs 3,822 learners You Will Learn How To oCategorize measuring instruments and know how to repair ... oRecognize the measurement of electric resistance oCompare the basic types of instruments Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Cathodic Protection Engineering 10-15 hrs 4,366 learners You Will Learn How To oExplain the forms of corrosion that occur on metallic st... oCategorize various forms of corrosion oDiscuss the effects of microbes on electrode... Read More More Info Start Learning Overwhelmed by career choices? Let us guide you. Discover the career most suitable for you and get started in the field with a step-by-step plan. Get Your Plan Diploma Advanced Level engineering Diploma in Mechatronics 10-15 hrs 27,889 learners You Will Learn How To oState the basic components and examples of mechatronic s... oOutline the laws and key components of electrical circui... oDiscuss the principles of semiconductor devices oDistinguish between sensors and transducers Read More More Info Start Learning Certificate Advanced Level engineering Introduction to Tissue Engineering 2 - 3 hrs 2,538 learners You Will Learn How To oDiscuss tissue engineering and whole tissue replacement oIdentify implant-associated infections and their treatme... oDefine foreign body response (FBR) Read More More Info Start Learning Certificate Intermediate Level education Understanding Basic Electricity 2 - 3 hrs 26,171 learners You Will Learn How To oRecognize the relationship between current, resistance, ... oState Ohm's Law and how it applies to the direct current... oEvaluate the current, voltage, and resistance of a DC ci... oExplain Kirchhoff's current and voltage laws Read More More Info Start Learning Certificate Intermediate Level engineering Parallel Circuit Rules and Ohm's Law 2 - 3 hrs 2,883 learners You Will Learn How To oState the four parallel circuit rules oDescribe the differences between parallel and series ci... oSolve for total resistance in a parallel circ... Read More More Info Start Learning Certificate Beginner Level Information Technology Basics of Network Engineering 2 - 3 hrs 8,993 learners You Will Learn How To oDefine the term telecommunications along with the basic ... oIdentify the applications, characteristics, and distinct... oDiscuss the fundamental limitations and specifications f... oExplain the overarching concept and functiona... Read More More Info Start Learning Certificate Advanced Level education Introduction to Biomedical Engineering Theory 3-4 hrs 2,778 learners You Will Learn How To oList the areas covered by biomedical engineering within ... oDiscuss the primary biological systems included in the s... oExplain the various working principles of sen... Read More More Info Start Learning Diploma Advanced Level engineering Advanced Diploma in Principles of Industrial Engineering 20-30 hrs 6,519 learners You Will Learn How To oOutline the roles of industrial engineering oAnalyze the importance of a healthy organizational cultu... oAnalyze the required methods of site selectio... Read More More Info Start Learning Certificate Intermediate Level business Reliability Engineering Fundamentals - Enhanced Performance Levels 4-5 hrs 1,576 learners You Will Learn How To oDefine the concept of reliability oIndicate how organizations ensure their product's reliab... oContrast between reliability, durability, and... Read More More Info Start Learning Did you mean: diploma electrical engineering? 426 courses Certificate Intermediate Level management Practical Municipal Engineering: Managing Public Works and Urban Projects 2 - 3 hrs 514 learners You Will Learn How To oDefine municipal engineering and its impact on our urban... oExplain the diverse nature of the municipal engineering ... oDiscuss the tasks and responsibilities of the... Read More More Info Start Learning Diploma Advanced Level engineering Diploma in Engineering Fundamentals of Electric Vehicles 15-20 hrs 11,647 learners You Will Learn How To oDefine Ohm's law and Kirchhoff's first and second law oCalculate torque inside a PMDC motor oUnderstand the role of magnetic flux inside a... Read More More Info Start Learning Diploma Intermediate Level education Diploma in Mathematics for Engineering 15-20 hrs 2,102 learners You Will Learn How To oList terms associated with mathematical systems oDescribe the algebraic and geometric definitions of the ... oExplain how a quadratic equation takes the fo... Read More More Info Start Learning Certificate Intermediate Level health Fundamentals of Biomedical Engineering 3-4 hrs 268 learners You Will Learn How To oDefine bioinformatics and state its core principles oState the challenges of Sequence alignment and database ... oRecall some ethical considerations in biomedi... Read More More Info Start Learning Diploma Advanced Level engineering Diploma in Optical Engineering 10-15 hrs 2,138 learners You Will Learn How To oDescribe the meaning and importance of optical engineerin... oExplain the basics of optical engineering using different... oAnalyze how light travels in a homogeneous medium and th... oExplain the parameters of the transverse magn... Read More More Info Start Learning Certificate Beginner Level engineering Series Parallel Circuits and Ohm's Law 2 - 3 hrs 3,370 learners You Will Learn How To oState the four series circuit rules oRecall the four parallel circuit rules oDescribe the differences between series circu... Read More More Info Start Learning Certificate Intermediate Level Information Technology Prompt Engineering for AI Applications 2 - 3 hrs 8,332 learners You Will Learn How To oAnalyse real-world examples to comprehend the profound i... oDiscuss effective techniques for leveraging language mod... oEvaluate the effectiveness of prompt engineer... Read More More Info Start Learning Certificate Advanced Level education Tissue Engineering and Material Characteristics 6-10 hrs 1,708 learners You Will Learn How To oOutline the role of Hydrogels in Tissue Engineering oIdentify the various methods and materials required to p... oDiscuss the applications of Bioceramics in Ti... Read More More Info Start Learning o40 Million + Learners o8 Million + Graduates o193 Countries Certificate Intermediate Level education Introduction to Environmental Engineering 3-4 hrs 2,091 learners You Will Learn How To oDefine various terms used in environmental engineering oAnalyse the interdependence of living and non-living ele... oIdentify different forms of air and water pol... Read More More Info Start Learning Certificate Advanced Level engineering Primer on Electrical Transducers 4-5 hrs 459 learners You Will Learn How To oAnalyze the characteristics of transducers oDescribe temperature transducers oRecognize a resistive strain gauge oDefine the linear variable differential trans... Read More More Info Start Learning Certificate Advanced Level Information Technology Fundamentals of Sound Engineering 3-4 hrs 1,955 learners You Will Learn How To oDefine the fundamental properties of sound, including fr... oDescribe how sound travels through different mediums and... oExplain the stages of signal flow from sound ... Read More More Info Start Learning Certificate Intermediate Level engineering Fundamentals of Environmental Engineering 3-4 hrs 2,544 learners You Will Learn How To oRelate environmental chemistry and microbiology concepts... oDescribe bacteria, fungi, algae and protozoa along with ... oDistinguish between the physical and chemical... Read More More Info Start Learning Certificate Beginner Level engineering Intelligence Electrical Devices and Digital Electrical Circuits 2 - 3 hrs 2,676 learners You Will Learn How To oDistinguish a binary number system from the decimal numb... oSolve the addition, subtraction and multiplication of tw... oCategorize the different logic gates into bas... Read More More Info Start Learning Certificate Advanced Level engineering Introduction to Optical Engineering 4-5 hrs 1,249 learners You Will Learn How To oDiscuss the meaning and historical background of optical... oExplain the concept and application of Gaussian beams to... oAnalyze how light travels in a straight line ... Read More More Info Start Learning Certificate Beginner Level engineering Mechanical Engineering - Internal Combustion Engine Basics 2 - 3 hrs 106,438 learners You Will Learn How To oDescribe how petrol and diesel engines work oExamine how internal combustion (IC) engines work Read More More Info Start Learning Certificate Beginner Level engineering AC Circuit Analysis: The Fundamentals 2 - 3 hrs 1,748 learners You Will Learn How To oDistinguish between AC and DC circuits oExplain why AC currents are used in the transmission of ... oCompute the RMS value of the voltage and cur... Read More More Info Start Learning Overwhelmed by career choices? Let us guide you. Discover the career most suitable for you and get started in the field with a step-by-step plan. Get Your Plan Diploma Advanced Level engineering Diploma in Audio System Engineering 10-15 hrs 29,443 learners You Will Learn How To oDiscuss sound as a pressure wave and its mode of propaga... oList the necessary specification design for certain soun... oDiscuss the process of sound propagation Read More More Info Start Learning Diploma Advanced Level engineering Advanced Diploma in Principles of Engineering System Design 15-20 hrs 4,010 learners You Will Learn How To oExplain a systems engineering plan for a project oCompare the applicability of any proposed process strate... oArrange the most essential systems engineerin... Read More More Info Start Learning Certificate Beginner Level engineering Gas Engineering: Concepts and Techniques 4-5 hrs 3,250 learners You Will Learn How To oList the typical duties of a gas engineer oIdentify qualifications necessary for employment as a ga... oDescribe gas piping materials and what you ne... Read More More Info Start Learning Certificate Beginner Level engineering Comprehensive Guide to Portable Appliance Testing 2 - 3 hrs 4,086 learners You Will Learn How To oDefine 'portable appliance testing' (PAT) oSummarise the purpose and importance of portable applian... oAnalyse the relationships between electrical ... Read More More Info Start Learning Diploma Advanced Level engineering Advanced Diploma in Engineering Thermodynamics 15-20 hrs 5,945 learners You Will Learn How To oDescribe the basic concepts of systems and states oIllustrate property diagrams of pure substances oSolve energy balance problems associated with... Read More More Info Start Learning Certificate Intermediate Level engineering Electric Power Metering - Single and 3-Phase Systems 3-4 hrs 2,947 learners You Will Learn How To oDefine power and energy oSummarize how to calculate power consumed by an AC circ... oDescribe phasors and their polar and rectangu... Read More More Info Start Learning Certificate Advanced Level education Engineering Calculus Simplified (Derivatives) 3-4 hrs 1,742 learners You Will Learn How To oExplain the sin function and its derivative oExplain the Cartesian coordinates system Read More More Info Start Learning Certificate Advanced Level engineering Introduction to Principles of Industrial Engineering 3-4 hrs 1,971 learners You Will Learn How To oOutline the roles of industrial engineering oCompare the general and specific objectives of industria... oExplain the functions of industrial engineeri... Read More More Info Start Learning Did you mean: diploma electrical engineering? 426 courses Certificate Intermediate Level engineering Electric Power Metering - Single and 3-Phase Systems 3-4 hrs 2,947 learners You Will Learn How To oDefine power and energy oSummarize how to calculate power consumed by an AC circu... oDescribe phasors and their polar and rectangu... Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Power System Protection - An Introduction 5-6 hrs 3,806 learners You Will Learn How To oExplain the different types of faults in a power system ... oContrast the different types of relays based on their co... oOutline the application of the different type... Read More More Info Start Learning Certificate Advanced Level Information Technology Basics of Prompt Engineering 2 - 3 hrs 9,582 learners You Will Learn How To oExplain how to design a prompt oIndicate how to set up your environment and install the ... oDiscuss basic prompting methods oExplain advanced prompting methods such as Z... Read More More Info Start Learning Certificate Intermediate Level engineering Utility Distribution Stations and Feeder Protection 3-4 hrs 2,887 learners You Will Learn How To oRecall the basic types of distribution in substations an... oExplain per-phase analysis and recall the procedures for... oIdentify substation components Read More More Info Start Learning Certificate Beginner Level business A Beginner's Guide to Feature Engineering 3-4 hrs 219 learners You Will Learn How To oDefine feature engineering, the way it works, and its pr... oList the essential processes of feature engineering oDescribe different techniques in feature engi... Read More More Info Start Learning Certificate Beginner Level engineering Symmetrical Components in Three-Phase Systems 2 - 3 hrs 833 learners You Will Learn How To oExplain Fortescue's theory of symmetrical components oDistinguish the notation used to represent the phases an... oIdentify an unbalanced and a balanced three-p... Read More More Info Start Learning Certificate Advanced Level engineering Introduction to Engineering System Design & Processes 3-4 hrs 2,857 learners You Will Learn How To oExplain why we need to have system engineering as a separate discipline oDefine the concept system engineering and the ... Read More More Info Start Learning Certificate Beginner Level education Understanding Thermodynamics for Science and Engineering 2 - 3 hrs 6,937 learners You Will Learn How To oDescribe the essential properties of gases and liquids oCalculate an ideal gas P x V = K, where P = Pressure, V ... oDefine temperature and how it affects pressur... Read More More Info Start Learning o40 Million + Learners o8 Million + Graduates o193 Countries Certificate Intermediate Level engineering Principles of Circuit Diagrams and Blueprint Reading 4-5 hrs 3,625 learners You Will Learn How To oDefine the workings of the electromagnetic relay and typ... oIdentify the power contactor, relay chatter, relay reset... oExplain the principle of electromagnetic rela... Read More More Info Start Learning Certificate Intermediate Level engineering Soil and Water Conservation Engineering - Introduction to Erosion Control Measures 2 - 3 hrs 1,955 learners You Will Learn How To oDiscuss the general features and adaptability of bunds a... oIdentify the various types of bunds and terraces oEvaluate the available data for designing soi... Read More More Info Start Learning Diploma Advanced Level education Advanced Diploma in Genetic Engineering - Theory and Application 20-30 hrs 3,508 learners You Will Learn How To oDescribe the concept of biotechnology oDiscuss the important milestones in biotechnology oList the enzymes involved in molecular cloni... Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Soil and Water Conservation Engineering 10-15 hrs 5,621 learners You Will Learn How To oExplain the fundamentals of soil erosion processes oDiscuss soil conservation measures in detail oDescribe how to utilize the available data fo... Read More More Info Start Learning Certificate Advanced Level Information Technology Fundamentals of Product Development and Systems Engineering 4-5 hrs 786 learners You Will Learn How To oRecognize how product development takes place in a stepw... oIdentify the three different life cycle models to execut... oDefine the Waterfall approach, the iterative-... Read More More Info Start Learning Certificate Advanced Level engineering Principles of Industrial Engineering - Forecasting 3-4 hrs 983 learners You Will Learn How To oDefine the role of forecasting in industrial engineering oExplain the principles, techniques and applications of f... oOutline the methods used for forecasting poss... Read More More Info Start Learning Certificate Beginner Level education Introduction to Material Science 2 - 3 hrs 1,356 learners You Will Learn How To oDistinguish between material science and engineering oDescribe two- and three-dimensional crystal lattice syst... oExplain the crystal structure of crystalline materials oRecall the energy band structure of solids an... Read More More Info Start Learning Certificate Advanced Level engineering Electrical Circuits Laplace Transforms 4-5 hrs 875 learners You Will Learn How To oDiscuss the two ways to excite first-order circuits oExplain the sources of source-free Did you mean: diploma electrical engineering? 426 courses Certificate Advanced Level engineering Production Planning and Control in Industrial Engineering 4-5 hrs 9,257 learners You Will Learn How To oAnalyze the scope of production control and planning oDistinguish between production planning and production c... oDiscuss the objectives of material requiremen... Read More More Info Start Learning Certificate Intermediate Level education ChatGPT Prompt Engineering: From Beginner to Expert 3-4 hrs 3,940 learners You Will Learn How To oDiscuss the fundamental principles and best practices of... oCompare the capabilities and strengths of different vers... oSelect the right words and phrases for your p... Read More More Info Start Learning Certificate Intermediate Level engineering Marine Electrical - Electricity Laws and Circuits 4-5 hrs 649 learners You Will Learn How To oState the basic laws of electricity oDescribe energy and power oRecall Ohm's Law and how it relates to the ba... Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Automotive Systems Training 6-10 hrs 11,691 learners You Will Learn How To oOutline the components of the automobile chassis system ... oExplain the operating principles of a compression igniti... oList the components and requirements for desi... Read More More Info Start Learning Certificate Advanced Level engineering Per Unit Analysis: Single and 3-Phase Systems 6-10 hrs 543 learners You Will Learn How To oDescribe per-unit and per-phase analysis of power system... oOutline the normalization process for per unit analysis ... oEstimate base values of systems including pow... Read More More Info Start Learning Certificate Advanced Level engineering Fundamentals of MATLAB and Diffractive Optics in Optical Engineering 4-5 hrs 3,934 learners You Will Learn How To oDiscuss the concept of Python in optical engineering and... oExplain the variables of different types of operations o... oAnalyze the interference between two plane wa... Read More More Info Start Learning Certificate Intermediate Level engineering Superstructure Activities in Building Construction 4-5 hrs 3,544 learners You Will Learn How To oExplain the procedures for placing the starter concrete ... oDiscuss the process for the ground floor beam bottom arr... oExplain slab centring and placing of beam rei... Read More More Info Start Learning Certificate Beginner Level engineering Introduction to Algebra for Engineering 3-4 hrs 1,298 learners You Will Learn How To oDefine a mathematical system and its properties oList terms associated with mathematical systems oDescribe a group and its properties Read More More Info Start Learning o40 Million + Learners o8 Million + Graduates o193 Countries Certificate Beginner Level engineering Understanding Microcontroller Interfacing Using Different Elements 4-5 hrs 1,504 learners You Will Learn How To oExplain the concept of your PIC Microcontroller us... oRecall how to perform circuit simulations using Proteus ... oSummarize how to use PICSimlab to run simulat... Read More More Info Start Learning Certificate Beginner Level engineering A Practical Guide to Portable Appliance Testing (PAT) 3-4 hrs 6,375 learners You Will Learn How To oEvaluate risks associated with electrical appliances oCategorise electrical appliances based on various factor... oIdentify hazards in commonly used electrical ... Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Biointerface Engineering 10-15 hrs 489 learners You Will Learn How To oOutline the historical development of theories about int... oList the various categories of intermolecular forces oDescribe the relationship between wettability... Read More More Info Start Learning Certificate Advanced Level engineering Fundamentals of Ray Tracing Matrix and Principal Planes in Optical Engineering 4-5 hrs 372 learners You Will Learn How To oExplain the different techniques of the ray tracing matr... oDiscuss the concept of refraction at a planar boundary a... oDiscuss the ray tracing matrix using reflecti... Read More More Info Start Learning Diploma Advanced Level engineering Diploma in Environmental Geomechanics 15-20 hrs 4,221 learners You Will Learn How To oOutline the background and genesis of environmental geom... oDiscuss the scope and importance of environmental geomec... oExplain the composition and the mechanics of ... Read More More Info Start Learning Certificate Advanced Level engineering Fundamentals of Monochromatic and Chromatic Aberrations in Optical Engineering 4-5 hrs 326 learners You Will Learn How To oDiscuss the processes involved in ray tracing using opti... oExplain the concept of aberration as well as the compone... oDefine the numerical aperture and its functio... Read More More Info Start Learning Certificate Advanced Level business Fundamentals of International Diploma in Safety Engineering (IDSE) 2 - 3 hrs 1,603 learners You Will Learn How To oIllustrate how a PDCA cycle can help with the implementa... oList various key processes of an Occupational Health and... oDiscuss the correct way to report an OHSMS pl... Read More More Info Start Learning Certificate Beginner Level engineering Introduction to DC Generators 2 - 3 hrs 1,491 learners You Will Learn How To oExplain the working principles of DC generators oDiscuss the conversion of an AC generator into a DC gene... oDescribe the construction of DC generators oSummarize the components of an armature core ... Read More More Info Start Learning Certificate Advanced Level engineering Rotating Machinery 6-10 hrs 1,292 learners You Will Learn How To oDistinguish between the cross product and the dot produc... oDefine work, energy and power oExplain and compute torque acting on a loop of wire rota... oOutline the construction and working of DC ma... Read More More Info Start Learning Overwhelmed by career choices? Let us guide you. Discover the career most suitable for you and get started in the field with a step-by-step plan. Get Your Plan Certificate Beginner Level education Introduction to Trigonometry for Engineering 5-6 hrs 1,465 learners You Will Learn How To oIdentify the basic trigonometric identities oDefine trigonometric identity and solve to prove identit... oState the formulas for the sine, cosine and t... Read More More Info Start Learning Certificate Advanced Level engineering Marine Electronics - Principles of Electricity and Circuit Parameters 3-4 hrs 1,670 learners You Will Learn How To oExplain the standard symbols and units used in electroni... oDiscuss the basic science behind electricity oDescribe Electro-Motive Force (EMF) and elect... Read More More Info Start Learning Certificate Advanced Level engineering Fundamentals of Solar Radiation and Solar Cells 4-5 hrs 2,011 learners You Will Learn How To oExplain the importance of empirical equations for predic... oList the different correlations developed for estimating... oCompute the estimated hourly global, beam and... Read More More Info Start Learning Certificate Advanced Level engineering Beginner in Circuit Analysis 4-5 hrs 1,796 learners You Will Learn How To oAnalyze the ideal voltage and current sources oDescribe how to convert a current source to a voltage so... oOutline the effects of the series connection of DC volta... oDiscuss the connection of DC current... Read More More Info Start Learning Certificate Advanced Level engineering Engineering System Design: Modeling Techniques and Simulations 3-4 hrs 2,143 learners You Will Learn How To oIdentify commonly used methods for modeling. oDistinguish between the different Relationship Diagrams. oList the different methods of Data Modeling. Read More More Info Start Learning Certificate Intermediate Level management Safety Management in Construction 2 - 3 hrs 6,685 learners You Will Learn How To oList the factors that create complex safety challenges w... oOutline the causes of uncertainty in construction work a... oIdentify the types and expectations of an ade... Read More More Info Start Learning Certificate Intermediate Level engineering Marine Electronics - Battery Maintenance and Safety Procedures 4-5 hrs 1,047 learners You Will Learn How To oExplain the theory of electrolytic solution oAnalyze secondary cells and their working principles oRecall internal resistance and polarity of ba... Read More More Info Start Learning Top Free Courses For "diplome electrical engineering" Discover the best resources and courses on diplome electrical engineering - handpicked by experts Did you mean: diploma electrical engineering? 426 courses Certificate Beginner Level engineering Wiring Practice Essentials 3-4 hrs 6,537 learners You Will Learn How To oExplain the procedures for removing cable insulation and... oIdentify the type and size of cables for industrial wiri... oDescribe the different types and construction of cable j... oExplain the procedures to solder copper condu... Read More More Info Start Learning Certificate Advanced Level engineering Principles of Winding 4-5 hrs 1,769 learners You Will Learn How To oDiscuss the construction of DC generators oOutline the terminal identification of a DC compound mot... oOutline the key tools and materials as well as the proce... oAnalyze the theory, application and the two m... Read More More Info Start Learning Certificate Advanced Level Information Technology Arduino Mastery: Code, Circuits & Web Control 2 - 3 hrs 604 learners You Will Learn How To oIdentify components of the Arduino circuit effectively oExplain the fundamentals behind the structure of the Ard... oRecall the skills that are necessary for the ... Read More More Info Start Learning Certificate Advanced Level engineering Design of Electric Vehicle Batteries 6-10 hrs 7,194 learners You Will Learn How To oCompute charge-discharge cycles of an electric vehicle's... oExplain the battery capacity of electric vehicles oDiscuss the concept of depth of discharge Read More More Info Start Learning Certificate Advanced Level engineering An Introduction to Mechatronic Systems 2 - 3 hrs 3,993 learners You

Will Learn How To oDefine 'mechatronics' oSummarize the basic components of mechatronic systems oDescribe some examples of mechatronic systems Read More More Info Start Learning Certificate Intermediate Level health Hazardous Area Classification 2 - 3 hrs 2,493 learners You Will Learn How To oIdentify and explain the different hazardous zone classi... oDiscuss the temperature classification and group of gase... oOutline the various types of explosion-proof equipment a... oIdentify and handle ignition sources in hazar... Read More More Info Start Learning Certificate Beginner Level engineering Low Voltage Circuit Breaker Designing 2 - 3 hrs 3,401 learners You Will Learn How To oDiscuss short circuits and overload conditions oCompare the different types of circuit breakers oExplain why a circuit breaker has an advantag... Read More More Info Start Learning Certificate Intermediate Level engineering Vehicle MET Technician 2 - 3 hrs 5,274 learners You Will Learn How To oAssess the career perspectives and day-to-day duties of ... oIdentify the risks involved in a MET technician's work e... oList the basic precautions and safety measures that a ME... oIllustrate car chassis and other body panel p... Read More More Info Start Learning o40 Million + Learners o8 Million + Graduates o193 Countries Certificate Beginner Level management Maintenance and Control of Electric Motors 2 - 3 hrs 3,547 learners You Will Learn How To oExplain the various methods used in controlling an elect... oDescribe the various systems used in starting an electri... oList the common faults of an electric motor d... Read More More Info Start Learning Certificate Advanced Level engineering Engineering System Designs: Qualification Planning & Design Process 3-4 hrs 1,419 learners You Will Learn How To oDiscuss acceptance strategies oSummarize what the Auto-link system is. oExplain the mission of InSeKts. Read More More Info Start Learning Diploma Beginner Level engineering Diploma in Sensory Virtual Reality 6-10 hrs 1,778 learners You Will Learn How To oExplain the 'haptics' oExplain human haptics oDiscuss the use of kinesthetic devices and sy... Read More More Info Start Learning Certificate Intermediate Level engineering Arc Flash Safety-A Practical Guide 2 - 3 hrs 2,505 learners You Will Learn How To oOutline the meaning of arc flash, arc blast and electric... oList and discuss the heat intensity and impact of pressu... oDescribe the effects of arc flash incidents o... Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Biointerface Engineering: Surface Interactions and Modifications 10-15 hrs 500 learners You Will Learn How To oExplain the methods used in the characterisation of prot... oIdentify the various therapeutic solutions applied to th... oSummarise the sequence of the natural respons... Read More More Info Start Learning Certificate Intermediate Level engineering Protection and Control: High-Voltage Power Circuits 5-6 hrs 7,627 learners You Will Learn How To oOutline the elements of a substation oExplain high-voltage switch configuration and elements o... oDescribe protection relay schemes, the failur... Read More More Info Start Learning Certificate Advanced Level engineering Analysis of Resonant Circuits and Three-Phase Circuits 4-5 hrs 616 learners You Will Learn How To oDiscuss the resonance condition in the series circuits oAnalyze the resonance condition in parallel circuits oOutline the importance of resonance in the fi... Read More More Info Start Learning Certificate Beginner Level engineering Introduction to DC Motors 3-4 hrs 2,147 learners You Will Learn How To oExplain the difference between DC generators and DC moto... oDefine the principle of operation of DC motors oList the types of DC motors: series, shunt and compound ... oDescribe the characteristics of DC motors Read More More Info Start Learning Overwhelmed by career choices? Let us guide you. Discover the career most suitable for you and get started in the field with a step-by-step plan. Get Your Plan Certificate Intermediate Level engineering EV Charging Equipment and Installation Training 2 - 3 hrs 648 learners You Will Learn How To oState the reasons why Lithium-ion batteries have been ad... oDistinguish between the various types of electric vehicl... oSummarize the working principles of Level 1 a... Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Building Construction Methodology 6-10 hrs 14,325 learners You Will Learn How To oList the basic principles and tenets of building constru... oDifferentiate the nominal mix and design mix concrete ty... oIndicate the practicality and theory of one-w... Read More More Info Start Learning Certificate Beginner Level engineering Basics of Electricity: Resistance, Inductance & Capacitance 5-6 hrs 1,699 learners You Will Learn How To oAnalyze resistors and their combination with series, par... oDescribe capacitors and their combinations with series, ... oDiscuss inductors and their combination with ... Read More More Info Start Learning Certificate Beginner Level engineering Series Circuit Rules and Ohm's Law 2 - 3 hrs 2,518 learners You Will Learn How To oDefine at least five of the basic electrical terms prese... oList the three Ohm's law formulas oState the four series circuit rules Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Introduction to Building Construction 6-10 hrs 18,678 learners You Will Learn How To oOutline the sequence of a construction project oIdentify the software used for architectural drawing, st... oSummarize the basics of civil engineering Read More More Info Start Learning Certificate Beginner Level Information Technology A Practical Guide to Switchgear Maintenance 4-5 hrs 510 learners You Will Learn How To oIdentify the different types of switchgears and their di... oDiscuss the different voltage levels of power distributi... oList the importance of the switchgear in the ... Read More More Info Start Learning Certificate Beginner Level engineering Applied Electricity 4-5 hrs 2,446 learners You Will Learn How To oDiscuss the application of alternate current theory oDescribe the working of AC voltage and alternate and dir... oAnalyze simple continuous periodic waves and their appli... oExplain phasor representation and phase diffe... Read More More Info Start Learning Certificate Beginner Level education Maths for Engineering - Conic Sections and Logarithmic Functions 3-4 hrs 1,308 learners You Will Learn How To oDescribe how to generate conic sections oExplain how to derive equations of parabolas with horizo... oDiscuss how to graph parabolas and analyzing ... Read More More Info Start Learning Prev 1 2 5 6 7 17 18 Next Did you mean: diploma electrical engineering? 426 courses Certificate Advanced Level engineering Motors and Controllers for Electric Vehicles 6-10 hrs 9,377 learners You Will Learn How To oOutline Kirchhoff's first and second law oExplain the flow of electrical and magnetic energy insid... oCalculate torque inside a PMDC motor Read More More Info Start Learning Certificate Beginner Level Information Technology A Practical Guide to Switchgear Maintenance 4-5 hrs 510 learners You Will Learn How To oIdentify the different types of switchgears and their di... oDiscuss the different voltage levels of power distributi... oList the importance of the switchgear in the ... Read More More Info Start Learning Certificate Intermediate Level engineering Principles of Cathodic Protection 4-5 hrs 1,710 learners You Will Learn How To oIdentify the various categories of storage tanks oSummarize the principles of cathodic protection of engin... oDiscuss the functions of anodes in cathodic p... Read More More Info Start Learning Certificate Beginner Level engineering Heat Exchanger Types & Applications 2 - 3 hrs 9,493 learners You Will Learn How To oIdentify the common types of heat exchangers oRecognize the pros & cons of each heat exchanger type oList heat exchanger categories Read More More Info Start Learning Certificate Intermediate Level engineering Short Circuit Analysis of a Three-Phase HV System 3-4 hrs 825 learners You Will Learn How To oSummarize the need for short circuit analysis oOutline the benefits of short circuit analysis oList the various types of electrical faults Read More More Info Start Learning Certificate Advanced Level engineering Fundamentals of Circuit Analysis 4-5 hrs 1,463 learners You Will Learn How To oIdentify how to perform circuit analysis using Laplace t... oDiscuss the concept of transfer functions, and how to fi... oExplain the importance of the convolution integral and t... oDiscuss the graphical approach to evaluating ... Read More More Info Start Learning Certificate Intermediate Level engineering Solar Energy and Photovoltaic System Technologies 3-4 hrs 2,055 learners You Will Learn How To oDiscuss the initiative made to promote diversity and inc... oExplain the importance and applications of solar energy oIdentify various components of the solar ener... Read More More Info Start Learning Certificate Beginner Level engineering Petroleum Engineering Principles and Concepts 6-10 hrs 4,460 learners You Will Learn How To oDefine what petroleum is and identify different types of... oIdentify the four hydrocarbon types that make up crude o... oRecognise reservoir rock properties and speci... Read More More Info Start Learning o40 Million + Learners o8 Million + Graduates o193 Countries Certificate Beginner Level management Assured Equipment Grounding Conductor Program (AEGCP) - OSHA 2 - 3 hrs 927 learners You Will Learn How To oList the types of equipment needed to implement the prog... oList the procedures required for the AEGCP oApply the examples learned in this course to ... Read More More Info Start Learning Certificate Beginner Level personal-development Motorbike Maintenance for Beginners 2 - 3 hrs 9,647 learners You Will Learn How To oIdentify motorcycle troubleshooting problems oContrast the differences between a two-stroke and four-s... oDescribe the safety concerns of a motorcycle Read More More Info Start Learning Certificate Intermediate Level education Fundamentals of Workshop Technology 5-6 hrs 2,544 learners You Will Learn How To oExplain the operations of marking and measuring tools oDescribe the various procedures involved in wood handlin... oList out the applications of surface finish a... Read More More Info Start Learning Certificate Beginner Level engineering AC Circuits Power Analysis 3-4 hrs 1,091 learners You Will Learn How To oDefine energy, power and work oCompare electrical and generic energy, power and work oDiscuss power in reactive circuits oRecall the trigonometric identities Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Quantity Estimation and Cost Analysis - An Introduction 10-15 hrs 5,932 learners You Will Learn How To oDiscuss the importance of quantity estimation in a civil... oEstimate excavation, stone soling, sand filling and PCC ... oCompute the quantities of materials for footi... Read More More Info Start Learning Certificate Beginner Level personal-development Automotive Starting System Diagnosis 2 - 3 hrs 11,305 learners You Will Learn How To oState the purpose of the starting system oDescribe the main parts of the starter motor oLabel expected voltage areas by highlighting ... Read More More Info Start Learning Certificate Intermediate Level engineering The Finishing Activities in Construction Methodology 3-4 hrs 3,769 learners You Will Learn How To oDiscuss the finishing activities involved in building co... oIdentify the brick and block types used for erecting bui... oDescribe the process and procedures involved ... Read More More Info Start Learning Certificate Beginner Level Information Technology How to Become a Software Engineer 2 - 3 hrs 1,734 learners You Will Learn How To oDistinguish a software engineer from a hobbyist programm... oList out the different types of software engineers and t... oRecognize the general responsibilities of a s... Read More More Info Start Learning Overwhelmed by career choices? Let us guide you. Discover the career most suitable for you and get started in the field with a step-by-step plan. Get Your Plan Certificate Beginner Level Information Technology A Step-by-Step Guide to Microcontroller Interrupts 3-4 hrs 3,714 learners You Will Learn How To oDefine an interrupt oState how to code using MikroC Pro oSummarize how to design a circuit using Prote... Read More More Info Start Learning Certificate Beginner Level engineering Appliance Testing Fundamentals 4-5 hrs 4,364 learners You Will Learn How To oProvide a summary of portable appliance testing (PAT) oExplain the applicable legal provisions regarding PAT oDescribe what risk assessment entails oRecognise the classification of electrical un... Read More More Info Start Learning Certificate Intermediate Level engineering Introduction to Aircraft Design 2 - 3 hrs 15,452 learners You Will Learn How To oDiscuss the specifications and requirements of aircraft ... oDistinguish its phases and processes oOutline the concept and mechanics of the spiral design oDescribe the processes involved in requiremen... Read More More Info Start Learning Certificate Advanced Level education Applications of Biotechnology 3-4 hrs 6,197 learners You Will Learn How To oDiscuss the impact of biotechnology on grafting techniqu... oAnalyze how genetic engineering has aided the control of... oExplain the procedure for the preparation of culture med... oDiscuss the significance of biotechnology in ... Read More More Info Start Learning Certificate Beginner Level education Basics of Electricity and DC Circuit Analysis 2 - 3 hrs 3,556 learners You Will Learn How To oState what Ohm's law is oOutline what the three key components are and how they a... oDistinguish between conductors and insulators... Read More More Info Start Learning Certificate Advanced Level education Understanding Action Potentials in Neural Networks 3-4 hrs 741 learners You Will Learn How To oDefine 'action potentials' in neural and neuronal networ... oExplain the function of ion channels in the cell membran... oDiscuss mathematical models for the generatio... Read More More Info Start Learning Certificate Advanced Level education CLEP Pre-Calculus: Algebraic Basics 3-4 hrs 1,195 learners You Will Learn How To oDiscuss how complex numbers are formed from imaginary nu... oDescribe the component parts of complex numbers includin... oOutline the methods for performing simple to ... Read More More Info Start Learning Certificate Beginner Level engineering AC Motors 4-5 hrs 3,188 learners You Will Learn How To oExplain the various components of a single-phase inducti... oDescribe the starting methods of a single-phase inductio... oList down the types of connections in a three-phase indu... oSummarise the load-torque characteristics of ... Read More More Info Start Learning Did you mean: diploma electrical engineering? 426 courses Diploma Advanced Level engineering Advanced Diploma in Basic Electronics 10-15 hrs 12,011 learners You Will Learn How To oDiscuss the history of electronics and semiconductor tec... oDiscuss how to derive the most basic form of the BJT sma... oDiscuss the operation of precision half-wave ... Read More More Info Start Learning Certificate Advanced Level engineering Introduction to Basic Electronics 4-5 hrs 19,149 learners You Will Learn How To oDistinguish the history of electronics and semiconductor tec... oExplain the principle of superposition and how it applie... oRecall some useful theorems that are applicab... Read More More Info Start Learning Certificate Beginner Level engineering Wind Energy – From Wind Turbines to Grid Integration 2 - 3 hrs 20,297 learners You Will Learn How To oExplain how wind is produced by nature oList the components of a typical horizontal axis wind tu... oList the types of generators used in wind tur... Read More More Info Start Learning Certificate Intermediate Level engineering Introduction to Wind Energy 3-4 hrs 3,728 learners You Will Learn How To oDefine the concept of 'wind energy capture' oExplain the pattern of use of wind energy in the world oDescribe the different types of wind turbines oAnalyze the relationship between the power an... Read More More Info Start Learning Certificate Beginner Level education Beginner Magnetism 4-5 hrs 1,011 learners You Will Learn How To oDistinguish between different types of magnets oDiscuss the properties of magnets oExplain magnetic flux and magnetic field lines oDescribe the magnetic field of the earth i e g... Read More More Info Start Learning Certificate Intermediate Level engineering Process Isolation Standard for Engineers, Operators, and Technicians 2 - 3 hrs 456 learners You Will Learn How To oSummarise the requirements for an effective isolation sy... oIdentify the areas in a process plant where process isol... oExplain mechanical isolation and the steps in ... Read More More Info Start Learning Certificate Beginner Level business Project Management: The Basics 2 - 3 hrs 13,249 learners You Will Learn How To oAnalyze status reports containing valuable information a... oCompute a realistic budget that takes all costs of a pro... oDefine project management and state its three constraint... oDescribe deliverables and why these are impor... Read More More Info Start Learning Certificate Beginner Level engineering Basics of Concrete Testing 3-4 hrs 7,598 learners You Will Learn How To oDefine 'concrete' oList the various types of concrete oOutline the advantages and disadvantages of concrete oSummarize the properties of concrete in plast... Read More More Info Start Learning o40 Million + Learners o8 Million + Graduates o193 Countries Certificate Beginner Level Information Technology Introduction to Server Administration Services 2 - 3 hrs 15,624 learners You Will Learn How To oDescribe name resolutions, like DNS and their importance oExplain different directory services available for your ... oExplain how to create and set group policies Read More More Info Start Learning Certificate Beginner Level Information Technology AutoCAD: Beginner to Professional Training 5-6 hrs 57,765 learners You Will Learn How To oExplain how to develop basic drawings using an array of ... oCompare different ways of modifying existing drawings oList a variety of keyboard shortcuts professi... Read More More Info Start Learning Certificate Advanced Level education Basics of Molecular Genetics 2 - 3 hrs 2,816 learners You Will Learn How To oDiscuss the concepts, principles, and applications of mo... oExplain how genetic information is encoded, replicated,... oCompare the structure and compositions of DNA and RNA oSummarise the basics of genes, gene expressio... Read More More Info Start Learning Certificate Intermediate Level Information Technology How to Create Dot Matrix LED Displays with PIC Microcontrollers 2 - 3 hrs 128 learners You Will Learn How To oExplain PIC microcontroller wiring and programming oDefine dot matrix basic principles and internal structur... oList the steps in making a dot matrix LED dis... Read More More Info Start Learning Certificate Intermediate Level Information Technology PCB Design Mastery with Proteus 2 - 3 hrs 1,262 learners You Will Learn How To oDefine critical concepts and terms used in PCB design wi... oDescribe ISIS and ARES functionalities for effective PCB... oExplain the process of creating schematic diagrams in Pr... oIdentify essential tools and features availab... Read More More Info Start Learning Certificate Intermediate Level Information Technology HC-05 Bluetooth Module Interfacing with PIC Microcontroller 2 - 3 hrs 92 learners You Will Learn How To oExplain the uses of Bluetooth oOutline the applications of Bluetooth oSummarise the factors to consider while choos... Read More More Info Start Learning Diploma Advanced Level education Diploma in Geometry for General Studies 10-15 hrs 1,262 learners You Will Learn How To oDistinguish between conditional and biconditional statem... oSummarize symbolic logic and congruent triangles oList the methods for proving triangles congru... Read More More Info Start Learning Certificate Beginner Level Information Technology SQL Server 2014: Security Fundamentals 3-4 hrs 3,027 learners You Will Learn How To oDescribe the reason and importance of storing your data ... oExplain the importance of security in SQL Server oDiscuss essential security concept and how SQ... Read More More Info Start Learning Overwhelmed by career choices? Let us guide you. Discover the career most suitable for you and get started in the field with a step-by-step plan. Get Your Plan Certificate Beginner Level Information Technology How to Build Your Own Computer 2 - 3 hrs 11,957 learners You Will Learn How To oSelect the hardware components and parts required for bu... oRecall the step-by-step procedures for assembling a micr... oList the peripheral devices that aid the I/O operations ... oExplain how to install operating systems and ... Read More More Info Start Learning Diploma Intermediate Level engineering Diploma in Bar Bending Schedule Mastery 15-20 hrs 1,655 learners You Will Learn How To oEstimate the complete cutting length of a footing BBS ma... oDiscuss how to prepare an Excel sheet for your footing B... oOutline the IS: 2502 guidelines for the bendi... Read More More Info Start Learning tshingombe fiston Fri, Jul 26, 2024, 2:59 PM to ALISON, TSHINGOMBEKB, me esidential Wiring Residential electrical system includes an electrical supply, electrical service, nonmetallic-sheathed cable, nail-on device boxes, panel boards, and fixtures. Phases of residential electrical wiring include rough-in, trim out, testing, and troubleshooting. 2. Commercial Wiring Electrical installations in commercial structures contain many of the same elements as residential installations. The only difference is that in commercial electrical installations, conductors are typically installed in metal raceways. This aspect of the job requires the electricians installing the devices to be skilled in conduit bending procedures, too. 3. Industrial Wiring Because of the hazardous materials that exist in many industrial facilities, the installation and maintenance of electrical systems in these volatile environments must follow strict requirements. Conduit systems in volatile environments must be sealed to outside vapors and gases, and any potential sparking or arcing device must be enclosed within a special enclosure or casing to prevent the ignition of hazardous vapors that might be present. Industrial electricians are generally split into two groups: installers and maintenance personne esidential Wiring Residential electrical system includes an electrical supply, electrical service, nonmetallic-sheathed cable, nail-on device boxes, panel boards, and fixtures. Phases of residential electrical wiring include rough-in, trim out, testing, and troubleshooting. 2. Commercial Wiring Electrical installations in commercial structures contain many of the same elements as residential installations. The only difference is that in commercial electrical installations, conductors are typically installed in metal raceways. This aspect of the job requires the electricians installing the devices to be skilled in conduit bending procedures, too. 3. Industrial Wiring Because of the hazardous materials that exist in many industrial facilities, the installation and maintenance of electrical systems in these volatile environments must follow strict requirements. Conduit systems in volatile environments must be sealed to outside vapors and gases, and any potential sparking or arcing device must be enclosed within a special enclosure or casing to prevent the ignition of hazardous vapors that might be present. Industrial electricians are generally split into two groups: installers and maintenance personne Job Requirements in the Electrical Trade Click on the tabs to find out more about them: Residential Electricians Commercial Electricians Industrial Electricians Residential Electricians provide the complete electrical system in a residential structure, keeping in mind the safety precautions. A lack of safety measures may contribute to injury due to shock or fires. Elements of a residential wiring installation include installing the electrical s The key points from this module are: The electrical trade offers many job opportunities to work in residential, commercial, and industrial construction. Electricians are responsible for the installation and maintenance of electrical systems and equipment. Electricians working on residential and commercial projects require the same basic set of knowledge and skills. Industrial electricians must know the installation procedure for various types of conduit, large conductors, motors, and controls, as well as possess strong troubleshooting skills. The electrical wiring system for residential, commercial, and industrial projects varies, and a thorough knowledge of the requirements for each sector is a vital part of the job. Electricians working with industrial wiring and equipment are also required to know the safety procedures for handling hazardous materials. ervice entrance equipment, branch circuit conductors, device boxes, panel enclosures, over-current protective devices (circuit breakers), and fixtures such as lighting and smoke detectors. Re: Release resultat statement and finalize award diploma /irregularitarly case .re marker tshingombe fiston Mon, Feb 12, 2024 at 11:05 AM To: TSHINGOMBEKB TSHITADI , centraloffice@qcto.org.za, secretarydir@saqa.co.za, Qualification@qcto.org.za, Mahlangu.L@qcto.org.za, learnerenrolments@qcto.org.za, saqainfo@saqa.co.za, dfqeas@saqa.co.za, DGRegistry@treasury.gov.za, deregistrations@cipc.co.za, DSI-Notification , tshingombe fiston , confirmations@saqa.co.za Application Ref :Applications letter number : 2023/1226 ______________________________ ADRESS:PRIVATE BAG X 174 ,PRETORIA 0001 123 FRANCIS BAARD STREET PRETORIA TEL:0123235618 ______________________________ ENQUIRY NUMBER: DHET : DOCKET NUMBER :2023/1226 INFORMATION MANAGEMENT SYSTEM - INSTITUT COLLEGE NAME :ST PEACE COLLEGE -ID: NUMBER: TIRC0G000910610 -REGISTRATION NUMBER: STUDENT -CO70040101099 -SARS VAT NUMBER: 923228238 -MERSETA : 17_QA/ACC/1311/17 -SAQA REGISTRAR STUDENT NUMBER:210020223812,2004007064382. -email adress: tshingombekb@gmail.com -Alternate email address: tshingombefiston@gmail.com ______________________________ APPEAL DECISSION RESULT RELEASE: APPLICATION NUMBER: Saqa: institut foreign .saqa transcription meeting 71638 dr congo requirements grasuate award diploma nqf .high certificate no meeting .leave school .expended assessments exam d etat diploma .certificate professionel- certificate informatics mathematicsvoffics ; result outcom primarly status registration saqa asset 09121 .saqa institut 30_ 39 nc assess policy.IE099 .saqa id 67q0 certificate advance phase teach .n1 saqa id 63375.id 67491 entrance .n diplomat -Qualification title national N diplomat engineering. -nqf level:6 . -date submitted to dhet :1105/2023 -date process . DHET -Timebtable /50111002 -N1:engineering studie -ID:2004007064381 -ID:2100002023812 ______________________________ Dear .mr minister of education dhet and deputy member of dhet .tvet college examination directorat and authority competencies. Governments president l' mr tshingombe tshitadi ;acknowledge student st peace college candidat examination career student follow course in duty of rated in rsa 2019 to 2024 , i 'm appear to your department goverment institution for allegation view no result of statement id candidat engineering n1.,n2, n.3,n4 ,n3 and n diplomat saqa outcom in irregularity final n5.n6 /nqf 6. examination national examination was not delivery in the time external assessment commited irregularities. 1.my motivation and disciplinairy assessment submited by portofolio on line portal dhet release resultat statement and finalized award diplomat by examination commited irregularityb november invalide subject n3 trade theory electricakbtranscript the result of assessment was note release nron irregularity n3.subject n4 .subject fail druip result february 2022 .directorat assessment trascript material .statement affidavitsubmitted st peace college registrar shalom technical and afric institut college no result outcom .after 15 days was result scaling n1.n2.n3but statement didint come out not print out by registrations resonement inconvenianet. Arbitrary irregularity on february i submitted topics saqa qcto dhet email result of saqa documentation; filing dbe dhet the commited was under investigation soon to finalyse . 2. I received to dhet commited assessment examinations irregularities the retain , invalide subject 23 february 2022 the time table of n3 subject admnistration exam with those subject trade . electrical trade theory .4 subject november 2023 examination rhe result statement for last examination was not print outcome n1.n2 submited n3 last time table exam only last n4 exam statement print outcome and not time table for n6.,n5 received in examinations november suspension is 11 month for irregularity .follow tvet guideline assessment. Exam over the date insurence body frameworks qualification and labour department uif coud claim no outcom in career portal was outcom granted national fund skill for extra subject topics irregularity nwiten qcto practical was not granted scope portal research qcto . 3.allegation result statement retain dhet ,saqa n diploma n diplomat application for n4.6 diplomat final was no granted n6 final exam n5.n6.subject additional assessment information by institution isat icass. Ref outcome saqa result 16 jan 2023 on line marischen masoga send submission number foreing instrut inquerie 9370. Foreign institutions inquiries 6594 Section 29(a)policy criteria saqa nqf amanded march 2017 institut ...framework nqf foreign award must meet for recognise . Saqa accepted only qualifications official examination body country . external examination based , 26 july 2022. 4.allegation to qcto retain on ; saturday22 january 2022. ; with regard n certificate direction dhet education training (for n4_n6 n diploma or umalusi n3 can not assist with qcto issued Sat ..10 march 203 qxto .certificate@qcto.org.za answer soc please note that the qcto does not issue any of results -lindiwe grace 28 may 2023 inquire to national and assessment college .i have copied our QA unit they will be able to rspond to accordingly regardc Qcto khuluvhe labour market intelligences lmi esteemed stakeholder 21 aug 2023 was not grante - i receiving Allegation to saqa retain on.10 march 2023 procedure for evaluatiin pro forma invoice .copy id passport.copy final award graduation certificate. Copy of completed transcript mark sheet academic record.proof payment if not meetings requirements can resubmitted again.non compliant; 27 july 2021 application above doe s not meet saqa Final award school diploma degree certificate in 48h . -that my requested letter to the authority minister for my result statement certificat over the date review n diploma 24 month.18 month rated examination to resolve problem after examination irregularities material that final result n4 and new re certificate body insurence investigation result center assessment outcome years icass total for for my infront st peace college institu and external certificate n1.n3 afric training institut and shalom technical collection print out was not in my application for diploma response from dhet submitted to resolve conflic assessment examination. - your sincerly . Sign :Tshingombe Tshitadi ______________________________ An.n3 .in the relevant specialization area communication nqf level 4 in language teaching ..theoretical knowl2 and practical skills required and learning of institution offering . To be award the award qualification learners are to choose complete .business studie 0.5 years business studies . .N4 o.5 years duration 60 credits ..n5 (0.5 year duration)60 credit .n6 . 0.5 years duration 60 . 18 month practical .in casev years duration engineering studies .n4 (0.33 years duration) 40 creditb. N5 (0.33 years duration) 40 credits .N6 (0.33 year duration) 40 credit ..24 montts practical experience. N diploma 360 credit .180 awarded to experiential training business studie ..programme code n diploma engineering studie .electrical engineering. NQF qualification ID: 90674 .national engineering studies electrical engineering. NQF level 6; 360 credit credit . Saqa learning programme . N . tshingombe fiston Wed, Feb 7, 9:29 PM (5 days ago) to tshigombekb, mamba.a, lundt.s, tena.m, lutuka.m, president, esther.ramnutlla, dmandaha, callcentre, careerhelp, registraphel, me Appeal ,process academic Section -Student Name:tshingombe tshitadi -Qualification : saqa record academic institution name: foreign .st peace -college name: st peace college -Year of graduation:2020 to 2024 :management system information academic year: policy dhet ..policy number: saqa cat yet Policy st peace college quality system manage qms .lms - referral registrar attendance :Record irregularities material transcript and script submission statement and evidence years 2022 ,11 months feb 2023 register roll academics college basic and advance nqf policy criteria ______________________________ 1.Letter record academic and transcript academic : Consenting :asking to provide detail fir reasin course attended topics mark earner apply and refistrar keepinf record .-FROM:TSHINGOMBE TSHITADI TO: THE DHET DEPUTY MINISTER . MEMBERS OF ACADEMIC RECORD SAQA AND COLLEGE RECTRAR INSTITUT SUB : Dear : my name is tshingombe and i attended event from to in there rwite to request for for my transcript to apply for futher aduation i wish to express my sincer gratitude to your dhet college thing which have helped me in my profession. I wish to take studies at foreign institut saqa and college education and advanced field continuing assessment professional institution has requirements a full transcript from my former studies to check my eligibility to studie the course i hope saqa to start my studie on and the dealnje to submit the the requested document is kindlt send the transcript at your earliest so that i an submjt the documents on time i herbrey provide my student identif6 number end of birbe you access my file quickly kindlt send the transcip to my home please t . -in effect of irregularities transcript material februarie 2022 need submission statement dhet full completion and finalise marks out term that honor for me to be part of this excellent institution since mention period feel proud and privileges to informer that due to the high standards of education imported by this institution secure institution workplace soon noining process i would be great ful to you if you colomb sending me the requested do i graduation years . I hereby requested foil transcrip i eas students in journes from i graduate alumn of esteemed successful career engineering experience cvs on line student research. ______________________________ - Section : Ref: to maintaining record of academic achievement dhet .st peace college in saqa in order to maintaining acurate system student record lesson transcript student . -student record : attendance dhet and nated years and saqa years entry national frameworks qualification award degree diplomat graduation. Enrol course in st peace college. -academics performance record keep track . studdnts progress formal and informal assessment .portofolio Topics system -Authors :tshingombe tshitadi: loyality research papper college system. Management -methodology: description login topics and research topic college'son lines admnito upload information stuent to view marks exam . -advantages :the software verifications on line topics in trade national examination infornal and poe s icass submitted on line framework qualification nqf submittedinformationsupplementairy need to be record earn reward hondstly .. Result procdssing collegd need to try again and consol inspector information management systems -consol textbooks n1,n6 permit consol fire script audit material exam scan over the time dowload need to be record registration storage restoration - registrar next stepped record keeping earn reward honestly intellectual value credit challenges loyal compensation nated body frameworks qualification textbook cooking amandment pay information need reward earn on line microsoft database system collection and record process casebook bsaqa book examination topics .reward need amandment R5000 copyright textbook exam papper exam submitted need to returned explanation .textbook olding reviewers retrieve answering exam papper need to be recording because studets topics framework challenge textbook answering textbook dissertation on line consol result statement. Thank u for sincerely. Weighting of courses Certificate engineering studie / n diploma engineering Course in circuium Weighting of courses Industrial electronics n1 Engineering drawing n1 Electrical trade theory n1 Mathematics n1 Industrial electronics n1 Electrical trade theory n1 Mathematics n1 N2 SCALING PLACEMENT Industrial electronics n3 Electrical trade theory n3 Engineering science n3 Electro- technology n3 -Industrial orientation n3 -plant operation theory n3 -electro –technology n3 -electrical trade theory n3 Electrotechnichnics n4 Industrial electronics n4 Engineering science n4 Mathematics n4 Certificate Courses in Curriculum Census day enrolments Credit value of the course FTE student Total Industrial electronics n1 0.33 1 Engineering drawing n1 0.33 1 Electrical trade theory n1 0.33 1 Mathematics n1 0.33 1 Industrial electronics n1 0.33 1 Electrical trade theory n1 0.33 1 Mathematics n1 0.33 1 N2 SCALING PLACEMENT 0.33 1 Industriel electronics n3 0.33 1 Electrical trade theory n3 0.33 1 Engineering science n3 0.33 1 Electro- technology n3 0.33 1 -Industrial orientation n3 0.33 1 -plant operation theory n3 -electro –technology n3 -electrical trade theory n3 0.33 1 Electrotechnichnics n4 Industrial electronics n4 Engineering science n4 Mathematics n4 Subjects/ course circuium weight Scale topic/ tot COMPLETED YEARS / HOMEWORK CLASS WORK credit N Diploma Nqf 360 credit 360 Industrial electronics n1 - 100% ; 100% 0,30 y Engineering drawing n1 - 100 %; 100% 0,30 Electrical trade theory n1 - 100%; 100% 0,30 Mathematics n1 100% ; 100% 0,30 0,30 Industrial electronics n1 - 100% ; 100% 0,30 Electrical trade theory n1 -, - 100 %; 100% 0,30 Mathematics n1 -, - 100%; 100% 0,30 N2 SCALING PLACEMENT Industriel electronics n3 100%; 100% 0,30 Electrical trade theory n3 100%; 100% 0,30 Engineering science n3 100%; 100% 0,30 Electro- technology n3 100%,100% 0.30 -Industrial orientation n3 -plant operation theory n3 -electro –technology n3 -electrical trade theory n3 48% 19% 55% 27% 100% ;148% 100% ;119% 100% ;155% 100% ;127% Electrotechnichnics n4 18% 100% ;118% 0.30 Industrial electronics n4 19% 100% ;119% 0.30 Engineering science n4 35% 100% ;135% 0.30 Mathematics n4 30% 100% ;130% 0.30 Sub total credit qualifie Award certificate diplomat 251% 1900 %; 1751% 0.30x16 Irregularity final mark Subject : n3,n4,n5,n6 Scrip material evidence low assessment Progress marker N3 final certificate Electronical trade theory n3 - 100% ,100% 0.30 Electrotechnichnics n4 - 100% ; 100% 0.30 Industrial electronics n4 - 100% ; 100% 0.30 Engineering science n4 - 100% ; 100% 0.30 Mathematics n4 - 100% ; 100% 0.30 Electrotechnichnics n5 - 100% , 100% 0.30 Industrial electronics n5 - 100% ; 100% 0.30 Engineering science n5 - 100% ; 100% 0.30 Mathematics n5 - 100% ; 100% 0.30 Electrotechnichnics n6 - 100% ; 100% 0.30 Industrial electronics n6 - 100% ; 100% 0.30 Engineering science n6 - 100% ; 100% 0.30 Mathematics n6 - 100% ; 100% 0.30 Total rate For certificate Full tle equivalente 1300% +1800; 1300+1751 3051 % 1900 0.30 X 29 =5;57 PRATICAL PANEL WIRING ELECTRICAL . PLUMBING Total 100% 100% 200% Total pratical theoretical euivalent N diploma engineering electrical value Record academic ACREDITTION N DIPLOMA , ID 67109 N , N1 ID 673575.N3 ID 66881, ID 66960, ID 67005 Required information Submitted yes not Institut comment For officer only Annuel report form yes Good years Award Termination of agreemnt with other institut yes Good years Award The disclosure certificate as issued by the CIPC for Directors who have yes Good years Award - INSTITUT COLLEGE NAME :ST PEACE COLLEGE -ID: NUMBER: TIRC0G000910610 -REGISTRATION NUMBER: STUDENT -CO70040101099 -SARS VAT NUMBER: 923228238 -MERSETA : 17_QA/ACC/1311/17 -SAQA REGISTRAR STUDENT NUMBER:210020223812,2004007064382 Yes Yes Yes Yes Yes Yes Yes Yes Good years Award Show Navigation Menu Completed Training: Tshingombe fiston Title Type Completion Date Score Status Maximize Profitability and Operations Efficiency 2/3 Video 9/20/2024 Completed SDL V2 Developer Role Video 9/20/2024 Completed DirQ_GL13R7 Managing Offer Safety Risks External Content 9/20/2024 Completed Discover Zelio Control Relays Video 8/12/2024 Completed Schneider Electric's Vision Edge 2022: Powering Digital Transformation Video 3/5/2024 Completed Secure Power _Virtual Certification_ on demand 2021_ session 4 Video 1/24/2024 Completed Cooling Virtual Certification_on demand 2021_ session 2 Video 1/24/2024 Completed Technical Expert Assessment Video External Content 1/23/2024 Completed DirQ_GL36R00 Technical Expert Assessment External Content 1/23/2024 Completed Technical Expert Assessment Workflow External Content 1/23/2024 Completed Technical Expert Assessment GuideBook External Content 1/23/2024 Completed Schneider Electric Information Technology guide Material 1/23/2024 Completed Heating, Ventilation and Air Conditioning (HVAC): Discover the Machines Online Class 1/23/2024 0 Completed Room Ventilation And Airborne Disease Transmission In A Healthcare Setting Online Class 1/22/2024 Completed Ecostruxure Power: Energy Modeling and Verification (SSOW) Video 1/22/2024 Completed Vérification de la facture /EcoStruxure Power: Utility Bill Verification (French) Online Class 1/22/2024 Completed Discover Telemecanique Sensors Curriculum 1/22/2024 Completed EcoStruxure Power Operation: Ch7 - Add Mechanical Graphics and Controls Video 1/21/2024 Completed ASCO: Fundamentals in Technical Document Review Online Class 1/18/2024 Completed EBO 2023: Introduction to Docker Online Class 1/18/2024 Completed EcoStruxure Security Expert: Biometric Reader Integration 4.3 Video 1/15/2024 Completed Discover Harmony XB5S Biometric Switches Video 1/15/2024 Completed EcoStruxure Innovation Talk: Why Alarm Management is the tip of the iceberg- and the best indicator of a poorly performing control system Video 1/15/2024 Completed PowerTalks: Equipment Performance Video 1/15/2024 Completed EcoStruxure Building: Script Programming (Self-Study) Material 1/15/2024 Completed Drives: Fundamentals of Kinematics: Calculation Centrifuge Video 1/15/2024 Completed Gestion de la Capacité /EcoStruxure Power: Capacity Management (French) Online Class 1/15/2024 Completed ASCO: Low Voltage Construction Fundamentals Online Class 1/15/2024 Completed Physical Infrastructure Management Basics Online Class 1/14/2024 Completed Fundamentals of Physical Security Online Class 1/14/2024 Completed Schneider Electric Approved EV Installers : IT Architecture Material 1/13/2024 Completed Advanced Lighting Control with KNX and DALI Online Class 1/13/2024 0 Completed ASCO: Application of Circuit Breakers in Power Control Systems Online Class 1/13/2024 Completed Security Expert Transition Guide Material 1/13/2024 Completed Discover Wiring Devices: Technical Structure and Applications Online Class 1/12/2024 0 Completed Internet: 50+ Years of Innovations and Inventions that Made It Curriculum 1/12/2024 Completed Computer History in a Photo Album Curriculum 1/12/2024 Completed Digital Economy: Movers and Shakers Curriculum 1/12/2024 Completed Your Computer's Secrets Curriculum 1/12/2024 Completed Teaching Computer Curriculum 1/12/2024 My Courses: Tshingombe fiston Use the transcript to manage all active training. 0 HRS AGGREGATE TRAINING COMPLETED FISCAL YEAR ENDING 12/31/2025 COST R0.00 Filter by Training Status Completed Sort by Completion Date Filter by Training Type All Types Search by Keyword Search Search Results (42) =Maximize Profitability and Operations Efficiency 2/3 Completed : 9/20/2024 Status : Completed Training Type : Video Training Status : Completed SDL V2 Developer Role Completed : 9/20/2024 Status : Completed Training Type : Video Training Status : Completed training Details Training Type: Curriculum Provider: Home and Distribution Academy Version: 30.0 Structure History Training Hours: 3 Hours 39 Minutes Description: Schneider Home Certification training is designed to equip installers with the knowledge and skills required to successfully deploy Schneider Electric's newest innovation in home energy management, the Schneider Home energy management system. This course delivers in-depth and comprehensive instruction on everything you need to know on how to properly install and commission Schneider Home suite of products. It covers the following topics: • Installing and wiring Schneider Inverter, and Boost, Pulse Backup Controller - wall mount. • Installing Schneider Energy Monitor and Square D Relays (if installing Schneider Energy Monitor in Pulse Backup Controller) • Commissioning with eSetup App and Smart Panel Setup App • Using Schneider Electric Installer Portal • Preparing for Handoff to the Homeowner • Accessing Schneider Home Resources • RMA Instructions and Warranties • Contacting Technical Support At the end of the course, you will take a 25-point Certification Test. You must obtain an 80% passing score to receive your Schneider Home Certification. This course offers 3 NABCEP CEU credits. Course Code: HDAPRDCS0001005 Status: In Progress Training Purpose: Due Date: None Expiration Date: Curriculum Select a training view (Selection will cause the page to refresh) All Training Activated Training Not Activated Training Show Expired Training Title (Click on to see course description) Type Due Date Excused Required Status Options Details Schneider Home Certification courses (Min. required: 10) Section None Introduction to Schneider Home Online Class None No Completed (Equivalent) Launch | Register Schneider Inverter Online Class None No Not Activated Activate None Schneider Boost Online Class None No Pending Prior Training None Pulse Backup Controller Online Class None No Pending Prior Training None Load Control Online Class None No Pending Prior Training None Commissioning with Schneider Smart Panel Setup App Online Class None No Pending Prior Training None Commissioning with eSetup App Online Class None No Pending Prior Training None Schneider Home Handoff to Homeowners Online Class None No Pending Prior Training None Schneider Electric Installer Portal Online Class None No Pending Prior Training None Schneider Home Support for Installers Online Class None No Pending Prior Training None Schneider Home Certification Test (Min. required: 1) Section None Schneider Home Certification Test Online Class None No Pending Prior Training None TRAINING TRANSCRIPT FOR TSHINGOMBE TSHITADI List of completed activities from 3/10/2024 to 3/10/2025 Username: tshingombefiston@gmail.com Email: TSHINGOMBEFISTON@GMAIL.COM Primary domain: Global SCM Primary organization: Primary job: User number: tshingombefiston@gmail.com ACTIVITIES Activity Signature Status Start Date Completion Date Learner Signature Date Score Attended Duration Completion Status e-Learning Course: Microgrid Modeling and Analysis 3/5/2025 3/5/2025 Day(s): 0, Hour(s): 0, Minute(s): 1, Second(s): 40 Attended e-Learning Course: Eaton: Supporting Your CDP Disclosure 2/23/2025 2/23/2025 Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 53 Attended e-Learning Course: Eaton's Low-Voltage Switchgear 2/22/2025 2/22/2025 Day(s): 0, Hour(s): 0, Minute(s): 2, Second(s): 26.3 Attended e-Learning Course: Eaton Electrical - SEM + Addendum 2/22/2025 16.67 Failed Day(s): 0, Hour(s): 0, Minute(s): 5, Second(s): 23 Attended e-Learning Course: Sales Training Exam: Eaton G4 Rack PDUs 2/22/2025 2/22/2025 55.55 Failed Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 59.2 Attended e-Learning Course: Sales Training Exam: How to Sell More Cables and Connectivity 2/22/2025 2/22/2025 80 Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 42.6 Attended e-Learning Course: Surge Solutions 2/22/2025 2/22/2025 25 Failed Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 10.3 Attended e-Learning Course: Power press Training Module 1 - PPE & Housekeeping 10/27/2024 2/22/2025 Day(s): 0, Hour(s): 0, Minute(s): 1, Second(s): 14 Attended e-Learning Course: Functional Skills Workshop: Human Resources [eLearning] 2/21/2025 2/21/2025 Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 19 Attended e-Learning Course: Power press Training Module 1 - PPE & Housekeeping 10/27/2024 10/27/2024 Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 17 Attended Transcript Records may take up to 24 hours to update. Transcript Legal name: Tshingombe Tshitadi Fiston 46307064 Edit display name in settings Username: 46307064 Edit user name in settings Contact email: tshingombefiston@gmail.com Edit contact email in settings Modules completed 924 Training hours completed 738 Hr 43 min Modules completed N/A in the module assessment result column means either the module assessment doesn't exist or there's no pass record for it. All modules in this table are complete. Module title Description Completed on Duration Module Assessment Result Introduction to Azure Load Balancer This module explains what Azure Load Balancer does, how it works, and when you should choose to use Load Balancer as a solution to meet your organization's needs. Jan 10, 2025 18 min N/A Enhance your service availability and data locality by using Azure Traffic Manager Discover how Azure Traffic Manager provides DNS load balancing for your application to improve the performance and availability of your application. Jan 10, 2025 29 min N/A Improve your reliability with modern operations practices: An introduction Discover a map for navigating reliability challenges and sustainably achieving the appropriate level of reliability in your systems, services, and products. Jan 10, 2025 10 min N/A diploma./irregularitarly case .re marker Inbox The Internet Archive Team (Internet Archive) Sun, Oct 20, 8:07 AM to me, Tshingombetshitadi, MMA, Msedusales ##- Please type your reply above this line -## You are registered as a CC on this request (1135821). Reply to this email to add a comment to the request. The Internet Archive Team (Internet Archive) Oct 19, 2024, 23:07 PDT It's dispiriting to see that even after being made aware of the breach 2 weeks ago, IA has still not done the due diligence of rotating many of the API keys that were exposed in their gitlab secrets. As demonstrated by this message, this includes a Zendesk token with perms to access 800K+ support tickets sent to info@archive.org since 2018. Whether you were trying to ask a general question, or requesting the removal of your site from the Wayback Machine—your data is now in the hands of some random guy. If not me, it'd be someone else. Here's hoping that they'll get their shit together now. TSHINGOMBEKB TSHITADI Oct 15, 2024, 09:19 PDT On Fri, 12 Jul 2024, 20:34 tshingombe fiston, wrote: Good morning On Fri, 12 Jul 2024, 14:47 tshingombe fiston, wrote: 2 Itter tshingombe self assesme Incident logged on 2024.docx 3formsubmission-request-ip-licence-mip-327-24-0100-000 sale force emet tshingombe.pdf 3letter explanation theoretical assessment learne application course topics textbook.docx 4formsubmission-request-ip-licence-mip-329-24-0100-000 assessment scotland,,theoretical pratical... 5formsubmission-request-ip-licence-mip-349-24-0100-000.pdf academic_transcript20240703-7-9m1civ met tableau record tshingombe.pdf Acrobat Document.pdf ah-engineering-science-data-booklet.pdf asses bigadie tableau 2.pdf asses worsale pdf assessment low become , question.pdf assess engi worksale.pdf traffic pdf 3.pdf assess engi worksale.pdf traffic pdf 3.pdf4.pdf5.pdf assess engi worksale.pdf traffic pdf 3.pdf4.pdf5.pdf6.pdf assess engi worksale.pdf traffic pdf 3.pdf4.pdf5.pdf6.pdf7.pdf assess engi worksale.pdf traffic pdf 3.pdf4.pdf5.pdf6.pdf7.pdf8.pdf assess engi worksale.pdf traffic pdf 3.pdf4.pdf5.pdf6.pdf7.pdf8.pdf8.pdf microsoft office1.pdf assess engi worksale.pdf traffic pdf 3.pdf4.pdf5.pdf6.pdf7.pdf8.pdf8.pdf microsoft office1.pdf ... assess wor sale.pdf assess worksale, pdf assessment help memo data ritgh tableaux, workforce, microsoft skill, alison,,,career path , sic... assessment licenseengineering printed scien license ip,tableaux,.pdf assessm worksale tshing.pdf assessment engineering electrical scoth.pdf assessment engineering electrical pdf tshingombe.docx assessment tableau tshingombe staus1.pdf assesworsale asses.pdf Assignment Cover Page - June 2019 (2).pdf badge asses career tshingombe.pdf brigade st peace colle tableaux.pdf CAREER CENTER FORM TSHINGOMBE.pdf Career Mentor - Construction Contractor Level 2 CareerInfo CareerInfoAwe2.pdf GE Unit_N4_EngineeringScience_AddedValueUnit.pdf course saqa complete,,.pdf CURRICULUM VITAE FOR KNOWLEDGE QINISO ZIKHALI 2023.pdf CURRICULUM VITAE FOR QINISO ZIKHALI 2023.docx CURRICULUM VITAE FOR QINISO ZIKHALI 2023.pdf CURRICULUM VITAE FOR QINISO ZIKHALI (October 2023).pdf DB5931 assessment.pdf digital psira aSSESSMENT ,PRE ASSMENT LEGISLATION CAREER , CCMA ,LABOUR ,,MET.docx DiscordSetup.exe english wor sale tshingombe.pdf badge creyiffacte workforce sale.pdf engin wor sale tshingombe.pdf new saves.pdf engineering printed scien license ip,tableaux,.pdf engineering theoretical pratical job , (#1) · Issues · tshingombe _ engineering theoretical · Git... engineering tshingombe..windows ss.pdf Firefox Installer.exe Firefox.lnk form police.pdf formsubmission-feedback-about-website-ff-973-24-0100-ffc assess tshing met pdf.pdf formsubmission-request-ip-licence-mip-319-24-0100-000 assess police , emet.pdf formsubmission-request-ip-licence-mip-319-24-0100-000 assessment police pdf formsubmission-request-ip-licence-mip-327-24-0100-000 assessment tshingombe.pdf formsubmission-request-ip-licence-mip-332-24-0100-000 engineering.pdf G7TA15_G7TC16_HNC_HND_ElectrcalEngineering_arrangements assessment tshingombe.pdf G7TA15_G7TC16_HNC_HND_ElectrcalEngineering_arrangements-1,tshigombe scotish.pdf github reposition assessment.pdf gitlab scree short projecttest assaemnt.pdf Gmail - Tshingombe, you forgot somethingtableaux gtub, microsoft.htm Gr11-PS-P2-ENG-AFR-June-2022-Possible-Answers.pdf Gr11-PS-P2-ENG-AFR-June-2022-Possible-Answers.zip Guide-to-getting-started-in-Film-and-TV.pdf Click on any field below to edit it Page Title * Page URL * https://archive.org/details/one-drive-137-11-17-2024 Description * Topics * engineering college Subject Tags * engineering Creator tshingombe Date 2024-11-17 Collection * Community data Test Item No Language English License Creative Commons Attribution-NonCommercial-ShareAlike More Options Add additional metadata... : (remove) Drag and Drop More Files Here or Name Size x DATA RIGHTS 2024 (FOI) -S8 (INVALID REQUEST).pdf 127 KB OneDrive_110_11-17-2024.zip 116 MB OneDrive_137_11-17-2024.zip 1.3 GB OneDrive_138_11-17-2024.zip 91 MB OneDrive_251_11-17-2024.zip 266 MB OneDrive_269_11-17-2024.zip 221 MB OneDrive_355_11-17-2024.zip 292 MB OneDrive_383_11-17-2024.zip 299 MB Report annual training candit security tshingombe.docx 44 KB Flip Portoflio docket review rigth low complain again award diploma combination.docx 40 KB INC000025277051 PHL enquiry Inbox Nhleko, Gugu Tue, Mar 19, 2024, 12:39 PM to me Good day The DHET has received the below enquiry Kindly note that according to the records for this profile 2100002023812, the results for 2023/11 were released and sent to SHALOM TECHNICAL COLLEGE on 01/02/2024 waybill number 080057034873 (SkyNet couriers). Candidate does not qualify for an N3 certificate as he did not pass all subjects. For a candidate to be awarded with a diploma (as per the below complaint), they must achieve N4, N5 and N6 certificates plus relevant work experience then they may submit the application at the college. Regards Gugu Nhleko Helpdesk

Complains about : Service delivery Person / Ministry / Municipality: Department of Higher Education Preferred contact number : N/A Any other contact number : N/A E-mail : tshingombefiston@gmail.com Fax Number : N/A ID number : N/A Ref number : N/A Office where you complained : N/A Street : N/A Building name : N/A City : Johannesburg Office Contact Number : N/A Province : Gauteng Date of complaint : N/A Names of people not delivering service: N/A Where did it happen town / site / municipality: N/A Type of service : Citizen is requesting about the release of results statement and to award a diploma. Student ID: 2100002023812 Student name.tshingombe Tshitadi College institute name St peace college Exam :external shalom technical : 899993812 Afric policing institute Memorandum :2023/0508 See attachment for more information Citizen requests the Presidency to assist them Re: letter explanation theoretical pratical base work , n diplomat award engineering electrical JXL6JWJL31FNJY17GWWMWQ Inbox dfqeas Tue, Nov 5, 2:38 PM (12 days ago) to me Dear Mr/Ms Fiston, Thank you for your email. Please note that application for evaluation of foreign qualification is done online. Kindly use the link below for the application of evaluation of foreign qualifications. All applications are done online. https://dfqeas.saqa.co.za/dfqeas/user/home Attached are the guidelines for applications and the country specific requirements. Be aware that the maximum turnaround time for completion of the evaluation process is 90 working days. Kindly note that our system is not compatible with the iPhone, iPad, and MacBook; you are advised to use other devices. Ensure that your default internet browser is Google Chrome and that you are connected to mobile data rather than Wi-Fi. Kind regards, Ms. Malebo Ngobeni From: tshingombe fiston To: Confirmations , , tshingombe fiston , , dfqeas , , Microsoft EDU Sales Date: 2024-10-23 09:12:08 Subject: Re: letter explanation theoretical pratical base work , n diplomat award engineering electrical On Sat, Sep 28, 2024 at 4:22 PM tshingombe fiston wrote: Hello dear how can gate my graduation ceremony certificate diploma engineering study n On Sat, 14 Sep 2024, 16:24 tshingombe fiston, wrote: hello dear i need help for my qualification issue rd congo saqa framework qualification supplementaire n diploma send to saqa Nhleko, Gugu Tue, Mar 19, 12:39 PM to me On Thu, Sep 12, 2024 at 11:47 PM Confirmations wrote: Good day How can i assist you? From: tshingombe fiston Sent: Sunday, June 23, 2024 12:07 PM To: tshigombekb@gmail.com ; tshingombe fiston ; dfqeas ; Lundt, Sonnika ; lutuka.m@dhet.gov.za ; careerhelp@dhet.gov.za ; maraba.a@dhet.gov.za ; callcentre@dhet.gov.za ; dmandaha@csir.co.za ; esther.rammutlla@dst.gov.za ; Confirmations ; President Hotline(DPME) ; modiba.d@dhet.co.za ; tena.m@dhet.gov.za ; QCTO Verification ; sonnika.s@dhet.gov.za ; SAQAInfo ; Microsoft EDU Sales ; sarb-graduaterecruit@resbank.co.za ; Nhleko, Gugu ; DSI-Notification ; Central Office ; Central Supplier Database System ; SARB Talent Acquisition ; study@stpeacecollege.co.za ; Secretarydr ; sarb-procurement@resbank.co.za ; csd@treasury.gov.za ; info@stpeacecollege.co.za ; ISCDSupport@dhet.gov.za Subject: re: letter explanation theoretical pratical base work , n diplomat award engineering electrical Re:/ award diplomat certificate,marksheet transcript letter experience theoretical practical engineering n studies outcome Inbox Address:postal. -Francis bard Pretoria Department of Higher Education and Training 123 Francis Baard Street, Pretoria Contact Nomo 506_012 312 5440 To:St peace college and instituts, tvet Dhet -Date :subject :completion letter : Practice experimental log book.______________________________ -1. To concerne This letter serves confirm .Mr was participations in the work integrated learning programme of department : Dhet research assessment irregularity national examination nated n4 to additional information and workbased on visited circular practice external on line job work practice on department of energy minimal compagny career CVS and industrial portal council work city power day visited on line Facebook,Gmail badges,Eskom career day 28day appointment,sarb career engineering artisan electrical electronics engineering,Microsoft Scheiner career certificate training, Eaton electrical dtic day project engineering ,sasseta saps psira career mil engineering career metropolitan ,log back project isita DBE and participate assessment engineering electrical for n studies engineering n diploma national framework work qualifications NQF saqa subject research engineering electrical at St peace college 20days work ,circulum on line computer practice topics research engineering electrical at 20 february 2022to 20 april 2024 in the area of engineering it expected following subjects. -Computer and information management system in education learn engineering assessment police and safety 1,and engineering safety security.class orientation guidelines./technical documentation libraries engineering lea Automatic reply: letter explanation theoretical pratical base work , n diplomat award engineering electrical Inbox CallCentre via dhetgovza.onmicrosoft.com Wed, Oct 23, 9:16 AM to me Please note that this is an automated response, do not reply to it. Thank you for contacting the Department of Higher Education and Call Centre. We appreciate your inquiry. Regarding NN Diploma, Nated, and NCV certificate enquiries: All applications for new issues, replacements, or combination requests must be submitted directly to the relevant college. Please note that there is a minimum waiting period of 3-6 months for diploma applications. The issuance of NN Diploma is currently paused. We have communicated this to all colleges. In the meantime, students whose diplomas are finalized but awaiting printing can obtain a confirmation letter from their college. We apologize for any inconvenience this may cause and appreciate your understanding.

Please tell us the name of the officer or member of staff you are working with in relation to this request

tshingombeeng

Submit